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CKM Workshop (MIT, Cambridge, MA; January 24, 2006

Context-Driven Decision Making in Network-Centric Operations: Agent-Based Intelligent Support

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Presentation Outline

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- Introduction
- Knowledge Logistics
- Context-Driven Methodology of Operational Decision Making
- System “KSNet” Research Prototype
- Case Study
- Conclusion & Future Work

SPIIRAS

Location of St.Petersburg

Russian Academy of Sciences

SPIIRAS

- Founded in 1724
- The research umbrella organization of the Russian Government
- Members of the Academy: Academicians – 458; Corresponding Members - 686
- 363 units (Research Institutes and Centers)
- 116,500 personnel: 55,100 Researchers (10,000 D.Sc., and 26,000 Ph.D.)

STRUCTURE OF THE RUSSIAN ACADEMY OF SCIENCES

PREZIDIUM
Yu. S. Osipov, President

Departments representing scientific fields

- Mathematical Sciences
- Physical Sciences
- Information Technologies & Computer Systems
- Power & Mechanical Engineering, Mechanics & Control Processes
- Biological Sciences
- Chemistry & Materials Science
- Social Sciences
- Historical & Philological Sciences
- Earth Sciences

Regional Branches

Far East	Siberian	Ural

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Amur	Buryat	Arkhangelsk
Kamchatka	Irkutsk	Komi
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Khabarovsk	Novosibirsk	Udmurt
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Sakhalim	Tomsk	
	Tyumen	
	Yakutsk	

Regional Scientific Centres

St. Petersburg
G.I. Alferov
Vice-President of RAS

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- Daghestan
- Kabardino-Balkariya
- Kazan
- Karelian
- Kola
- Puschino
- Samara
- Saratov
- Troitsk
- Ufa
- Vladikavkaz
- South

SPIIRAS

- St.Petersburg Institute for Informatics and Automation (SPIIRAS)
- Founded in 1978
- Only 1 Russian Academy of Science Institute operating in Northwest Russia in Computer Science discipline
- 210 Personnel: 167 Researchers (34 D.Sc., and 56 Ph.D., 37 Ph.D. students)
- Grants Ph.D and Dr.Sc. (Technical) degrees

URL: http://www.spiiras.nw.ru

SPIIRAS Research Directions

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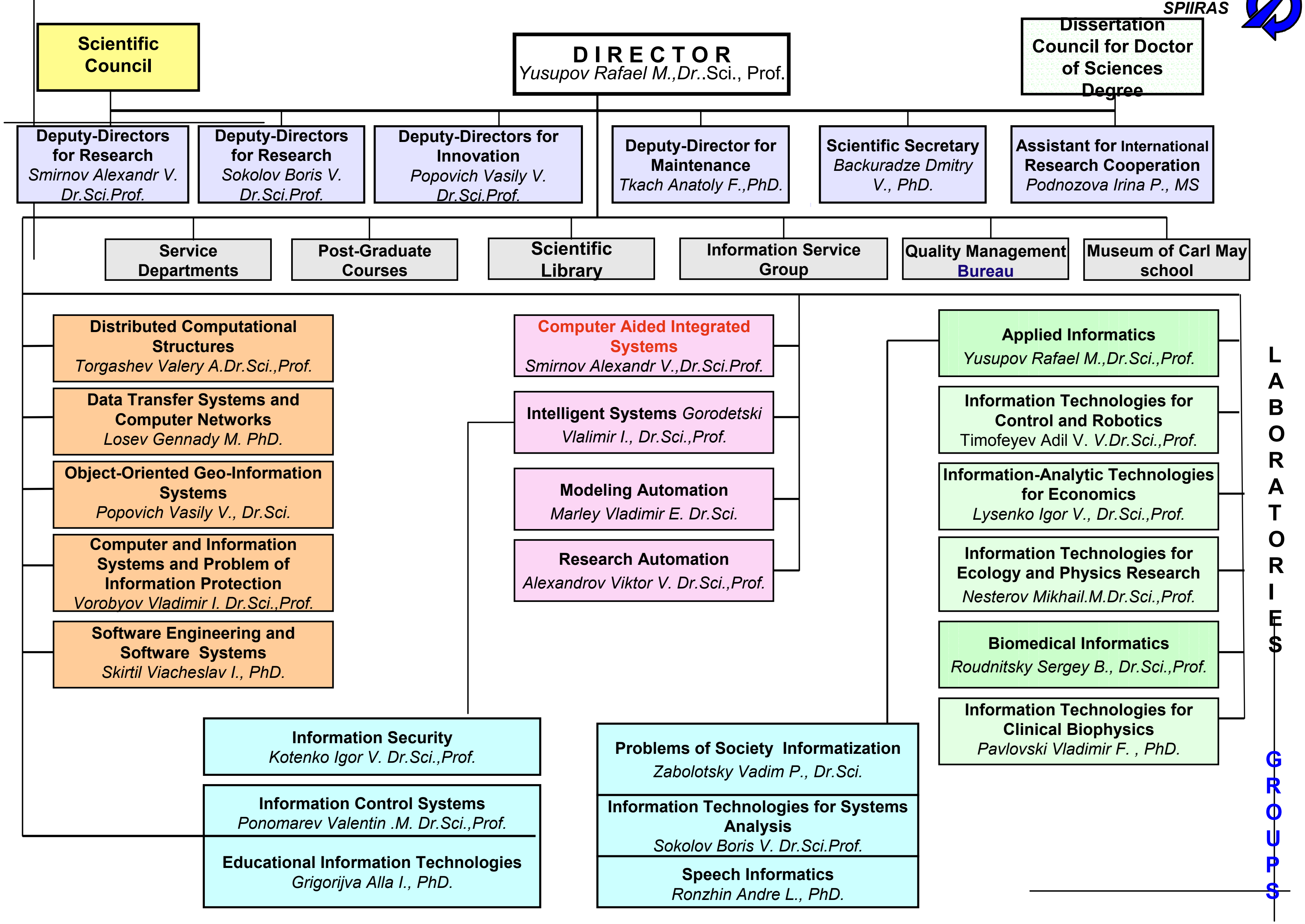
- Fundamentals of the Informatization of the Society and Regions, Regional Information and Computer Networks and Systems
- Architecture, System Decisions and Software Development for Information and Control Complexes for Real Time Signal Processing
- Fundamentals of Information Processes in Complex (Socio-, Eco-, Bio-,Geo-, etc) Systems
- Theoretic Basics in Developing Information Technologies for Research Automation, Control and Manufacturing Intelligent Systems

SPIIRAS STRUCTURE



CAIS Lab Research Collaboration History with US DoD Organizations

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- Ontology-Driven Information Integration from Heterogeneous Sources for Operational Decision Making Support *(US Office of Naval Research and US Air Force Research Laboratory, 2005-2006 – CRDF' project RUM2-1554-ST-05): Case Study – Humanitarian Logistics.*

  Due to this project SPIIRAS is the first (and currently the only one) Russian organization involved into joint research of US ONR and AFRL

- Mathematical Basic of Knowledge Discovery and Autonomous Intelligent Architectures: Knowledge Fusion in the Scalable Infosphere *(US AFRL, 2000-2003 – ISTC' project 1993P): Case Study – Mobile Hospital Configuration*

Collaboration with Ford

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- Ontology Modeling and Knowledge Integration for Supply Chain Management and Product Lifecycle Management (*Ford Research Lab, Dearborn, USA*, *2001-2005*)
- External Logistics Network Configuring for Russian Assembly Plant (*Ford Motor Company – Russia, St.Petersburg, Russia, 2001-2002*)
- Customer-Oriented Management of Vehicles Supply Chain Using Fuzzy Coalition Games (*Ford Research Center, Aachen, Germany, 1999–2000 - project*)
- Configuration and Optimization of Global Production Networks in Order to Improve Investment Efficiency over Total Facility Life-Time (*Ford Research Center, Aachen, Germany, for 1996-1999 - project)*

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CAIS Lab’ Current European Grants & Projects

- ILIPT - Intelligent Logistics for Innovative Product Technologies (*European Community – Research Program on Information Society Technologies, 2004-2007, – project IST-2002-507592*).

  Due to this project SPIIRAS is the first (and currently the only one) Russian organization involved into EU 6th FP projects related to the business area
- IMS-NoE – Intelligent Manufacturing Systems (*European Community – Research Program on Information Society Technologies, 2003-2006, – project IST-2001-65001).* **Due to this project SPIIRAS is the first (and currently the only one) Russian organization involved into Intelligent Manufacturing Systems Program**
- Knowledge Supply for Regional and Inter-Regional Networks of Small and Medium-Size Enterprises *(Swedish Foundation for International Cooperation in Research and Higher Education, 2003-2006)*
- Information Modelling for Multi-Lingual System Development Across the Extended Enterprise and Multi-Agent Systems (*Engineering and Physical Sciences Research Council, UK, 2003-2005)*
- Ontology-Based New Order Code Generation for Corporate Product Data Management System *(Festo, Germany, 2005-2006)*
- Ontology-Based Intelligent Access to Documents and Catalogues *(Festo, Austria-Germany, 2003-2005)*

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CAIS Lab' Current Russian Grants & Projects

- Methodological and Mathematical Foundations of Context-Driven Intelligent Decision Support Systems Development *(Russian Basic Research Foundation, 2005-2007 - project 05-01-00151)*

- Context-Driven Methodology of Distributed Systems Development for Intelligent Decision Making Support in Open Information Environment *(Presidium of Russian Academy of Sciences – Research Program on Mathematical Modeling and Intelligent System, 2004-2006 - project 16.2.35)*

- Theoretical Foundations and Multi-Agent Technology for Context Management in Open Information Environment *(Department of Information Technologies and Computational Systems of Russian Academy of Sciences – Research Program on Fundamental Basis of Information Technologies and Systems, 2003-2005, - project 1.9)*

Selected Publications

SPIIRAS

- Smirnov A., Pashkin M., Chilov N., Levashova T. and A. Krizhanovsky Agent-Based Intelligent Support to Coalition Operations: a Case Study of Health Service Logistics Support. *Information & Security. Special Issue on IT in Coalition and Emergency Operations.* Vol.16, 2005, pp. 41-61.
- Smirnov A.V., Pashkin M.P., Chilov N.G., and Levashova T.V. Knowledge Logistics in Information Grid Environment. *Future Generation Computer Systems*, 2004, 20 (1), pp. 61—79.
- Smirnov A., Pashkin M., Chilov N., Levashova T. KSNet-Approach to Knowledge Fusion from Distributed Sources. *Computing and Informatics*. V. 22, 2003, pp. 105—142.
- Smirnov A.V., Pashkin M.P., Chilov N.G., Levashova T.V. Agent-Based Support of Mass Customization for Corporate Knowledge Management. *Engineering Applications of Artificial Intelligence,* 16 (4), June 2003, pp. 349—364.
- Smirnov A., Pashkin M., Chilov N., Levashova T. Haritatos F. Knowledge Source Network Configuration Approach to Knowledge Logistics. *International Journal of General Systems*, 2003, 32 (3), pp. 251—269.

Introduction: Network-Centric Operations

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- Network-centric Operations exploit information and network technologies to integrate widely dispersed human *decision-makers*, networking *sensors*, and *resources* into a highly adaptive, comprehensive *network-centric environment* to achieve shared *situation* awareness and *unprecedented mission* effectiveness by efficient linking *knowledgeable components* in the environment

(Adapted from the Chief of Naval Research' definition of NCW, ONR BAA 05-013)

Introduction: Application Domains

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- Emergency preparedness and response (to terrorism attacks / incidents, catastrophic events, natural disasters, emergency situations, etc.)
- Global war on terrorism (GWOT) and Multinational operations other than war (OOTW)
- Intelligent transportation systems
- Supply chain management & e-Business
- Coalition health service logistics support
- …

Introduction: Decision Level Correspondence

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- *Strategic decisions* concern general directions, long-term goals and relationships.
- *Tactical decisions* take place within the context of strategic decisions. They are primary concerned with the most appropriate effective use of available resources.
- *Operational decisions* affect activities taking place *right now*. The tasks, resources, and goals of these activities have been set by strategic and / or tactical decisions.

Introduction:
Operational Decision Making Features

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- Coordination of different levels of decision making
- Management of huge amount of information and knowledge
- Intelligent sharing and reuse of information and knowledge
- Dynamic conditions
- Personalization of decision making (Intelligent Personalized Assistant)

- Decisions:
  - Problem (situation) specific
  - Timely
  - Alternative
  - Repeatable

Introduction: Operational DSS Reguirements

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- *Robustness:* the decision support system (DSS) should continue to operate even if some of its elements stop;
- *Sensitivity and Adaptability:* relationships between the system's elements organization's units has to be able to be easily and quickly readjusted in accordance with changes in the environment;
- *Intensive Knowledge / Information Exchange* between the system's elements: knowledge management de facto has become essential for decision making processes.

Introduction:
Five Key Characteristics of Team

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- Teams exist to achieve a shared goal.
- Team members are interdependent regarding some common goal.
- Teams are bounded and stable over time.
- Team members have the authority to manage their own work and internal processes.
- Teams operate in a social system context.

Sources:

- Alderfer C. Group and Intergroup Relations. In: J. Hackman and J. J. Suttle (eds.) Improving Life at Work. Palisades, CA: Goodyear, 1977
- Hackman J. Introduction: Work Team in Organizations: An Oriented Framework. In: J. Hackman (ed.) Groups That Work and those That Don’t. San Francisco, CA: Jossey-Bass, 1990

Introduction: What Kind of Networks Is Needed for Operational Decision Making?

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- Social networks
  - who knows whom => *Virtual Communities*
- Knowledge networks
  - who knows what =>*Human* & *Knowledge Management*
- Information networks
  - who informs what => *Internet/Intranet/Extranet/Grid*
- Work networks
  - who works where => *GroupWare*
- Competency networks
  - what is where => *Knowledge Map*
- **Inter-organizational network**
  - **organizational linkages => *Semantic-Driven Interoperability***

Introduction: Importance of Semantic-Driven Interoperability

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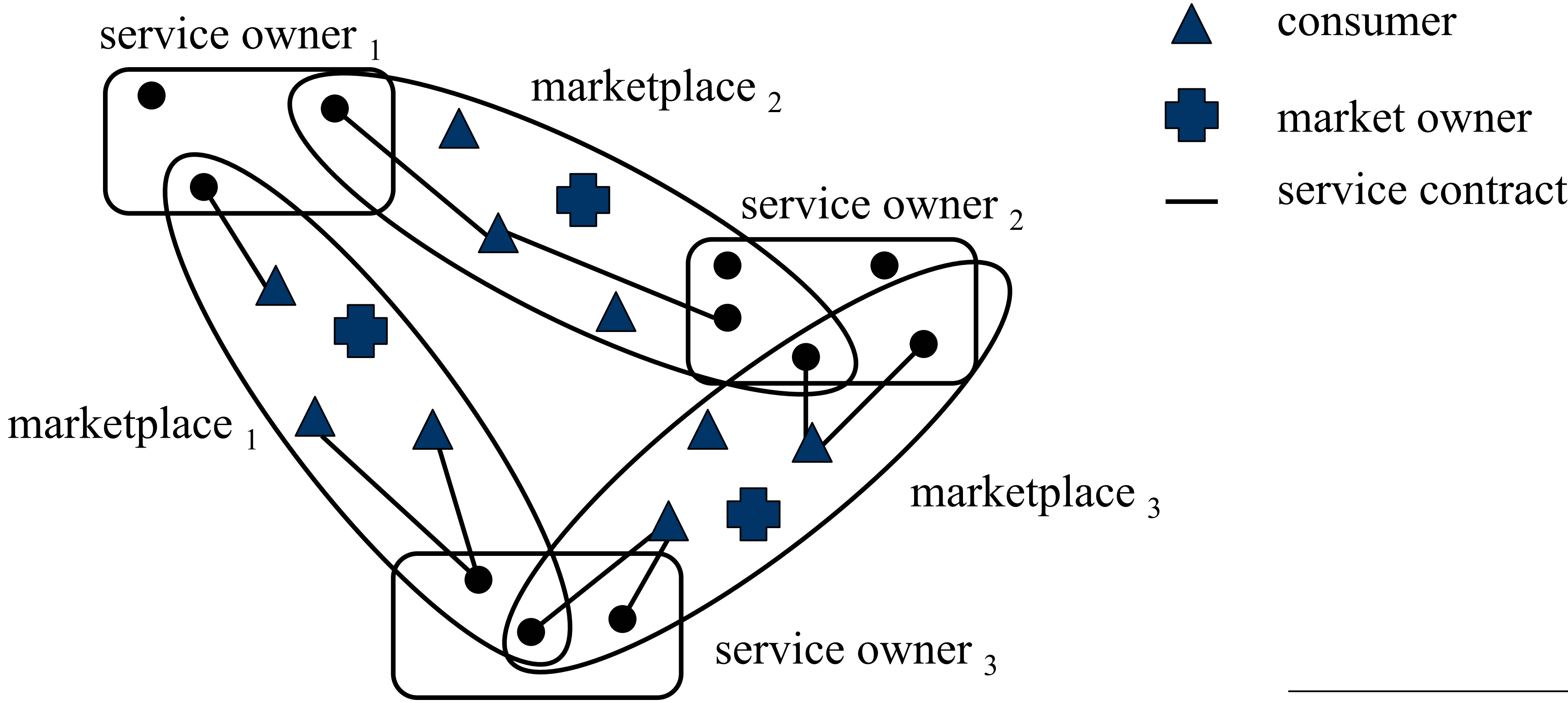
- Today the organizational competence is the function of collective intellectual capital (knowledge) of the network-centric environment across the decision lifecycle
- Decision knowledge is critical core competency for future. *Only 20% of a firm's knowledge is effectively used by today's organizations.*
- Different consumers (decision makers) of decision information look at it from *<u>different contexts (aspects)</u>*
- The major problem of modern DSSs is to provide a unified and complete view of all aspects of decision making to provide *<u>team decision</u>*

Introduction:
Network-Centric Environment Basis

- Intelligent Agents,
- Ontology Management, and
- Markup Languages
- ***Open Service Reference Model:***

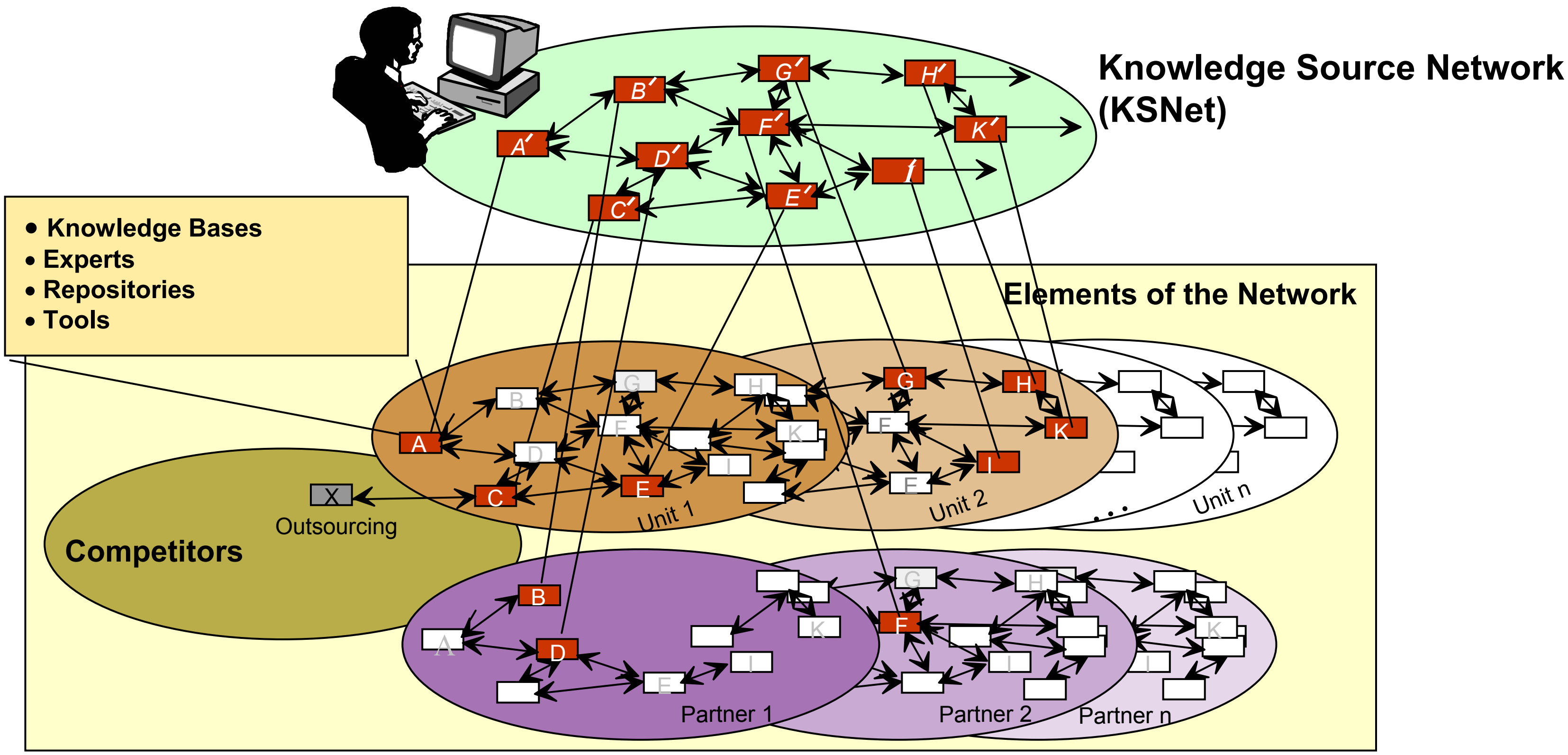


Knowledge Logistics: Definition

- Aim
  - Acquisition, integration, and transfer of the **right knowledge** from **right sources** in the **right context** to the **right person** in the **right time** for the **right purpose (6R or 6Right)**
- Conditions
  - Individual user requirements **(personalisation),**
  - Available knowledge sources **(information fusion),**
  - Current situation analysis **(context)**

Knowledge Logistics: KSNet-Approach

- Network of knowledge sources located in information environment is referred to as “Knowledge Source Network” (KSNet)
- KSNet originates from the concept “Virtual Organization” based on the synergistic use of knowledge from multiple sources



Knowledge Logistics: FIPA Ontology Definition

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- Ontology is an explicit specification of a *structure* of a certain domain
- Ontology includes a *vocabulary* for referring to a subject area, and a set of logical statements expressing the *constraints* existing in the domain and restricting the interpretation of the vocabulary
- Ontology provides a vocabulary for representing and communicating knowledge about some topic, and a set of *relationships* and *properties* that hold for the *entities* denoted by that vocabulary

- “I would say that all practical ontologies are *semiformal*, and the "sweet spot" is an ontology that specifies clearly how you can commit to it. Both the *formal and informal* parts should be designed to make it easy to play by the rules: the *formal by automated testing* and the *informal by well-written documentation*” – T. Gruber

(Thomas Gruber' interview available in AIS SIGSEMIS 1(3) 2004 http://www.sigsemis.org/newsletter/october2004/tom_gruber_interview_sigsemi)

Source: Foundation for Intelligent Physical Agents (FIPA), www.fipa.org

Knowledge Logistics: Ontology-Driven Methodology

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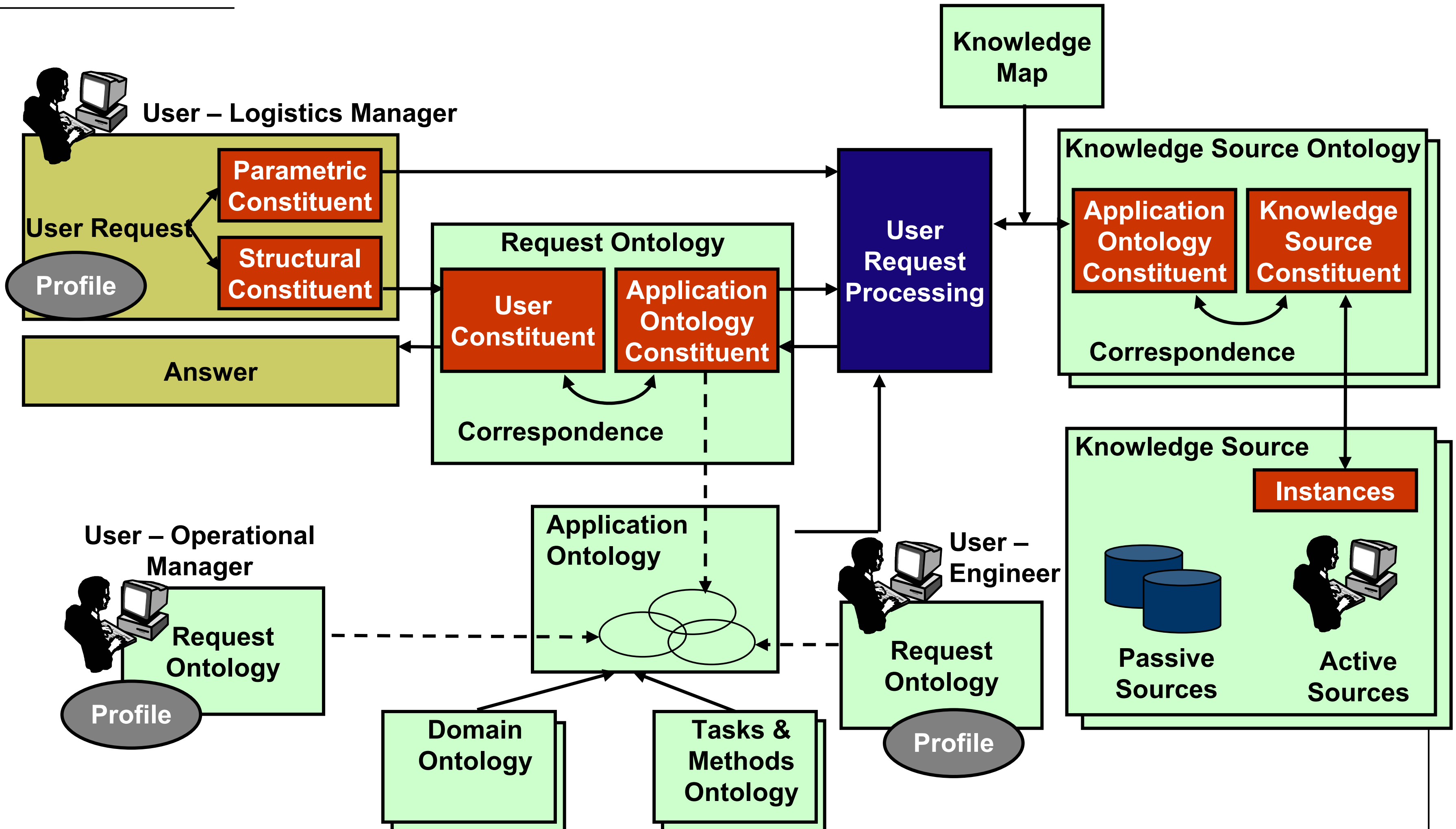

KL – Knowledge Logistics

Knowledge Logistics: Ontology-Driven Knowledge Sharing

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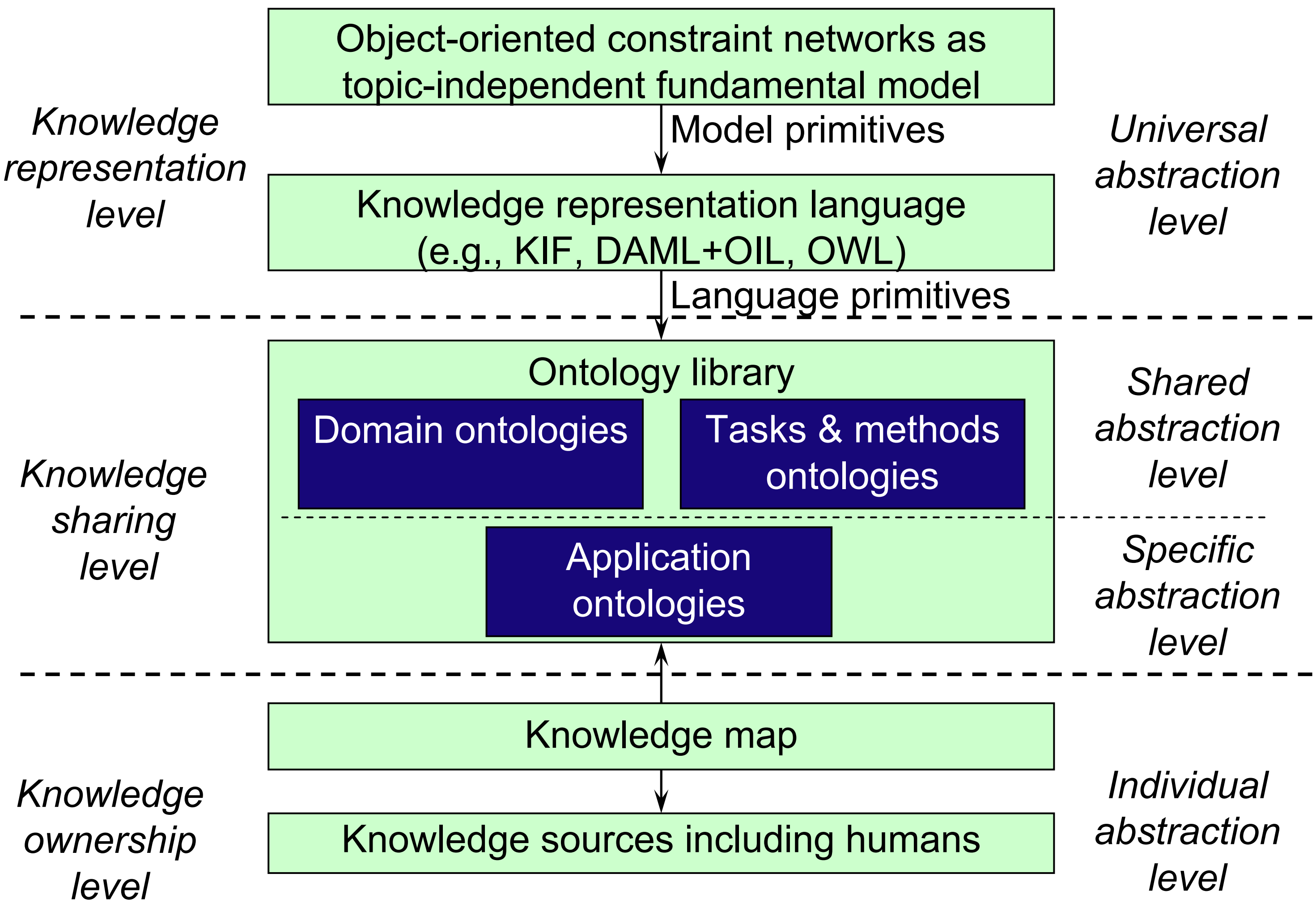

Context-Driven Methodology: Context Definition

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- *Context* is any information that can be used to characterize the *situation* of a component, where a component can be a *person, place, physical or computational object.*

- For problem solving *"context is what constraints a problem solving without intervening in it explicitly"* (Brézillon 1999).

Resource:

Brézillon P., "Context in problem solving: A survey", *The Knowledge Engineering Review*, vol. 14, no. 1, 1999, p. 1—34.

Context-Driven Methodology: Motivation

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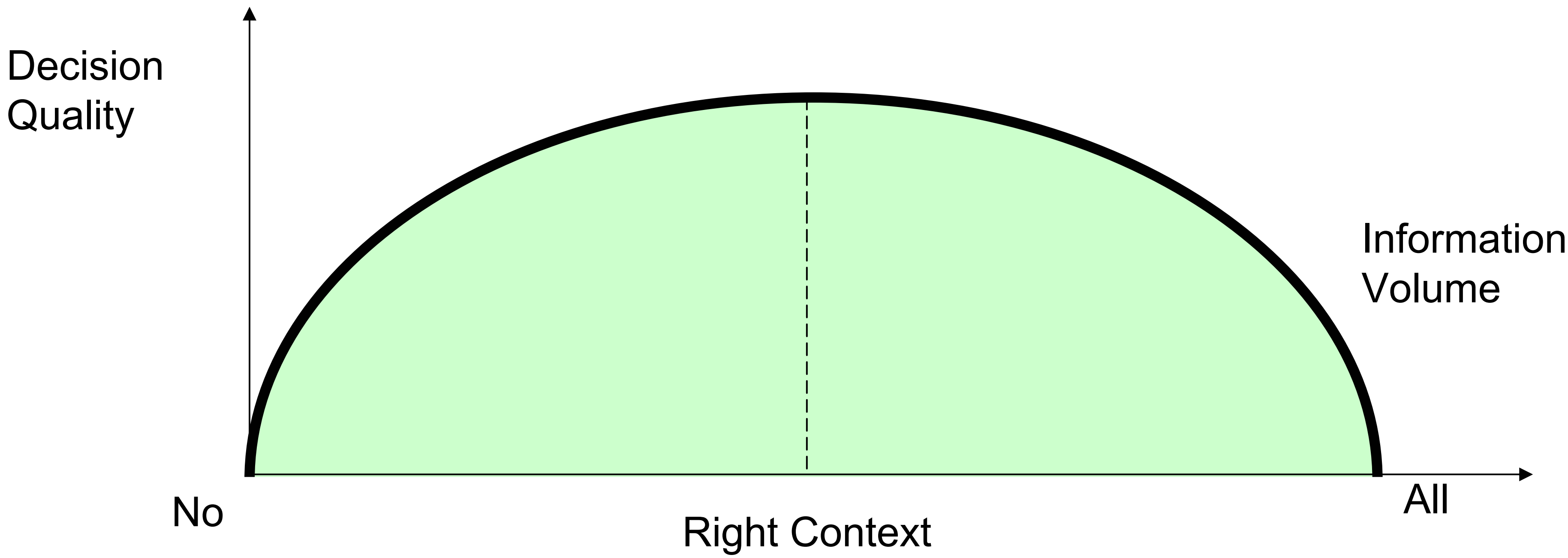

__Theorem 1:__ 50%of the problems in the world result from people using the same words with different meanings.
__Theorem 2:__ the other 50% of the problems results from people using different words with the same meaning.

Source: Kaplan S. The Words of Risk Analysis, *Risk Analysis*, Vol.17, N 4, August 1997

Context-Driven Methodology: Core Message

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- Contextual interpretation & integration of available mission-focused information for operational decision making is a key point to achieve effectiveness of network-centric operation mission based on the **Knowledge Logistics Tenet**:

  "The right information from right sources in the right context to the right person in the right time for the right purpose (operational situation)"

Context-Driven Methodology: Levels of Integration of Knowledge and Information

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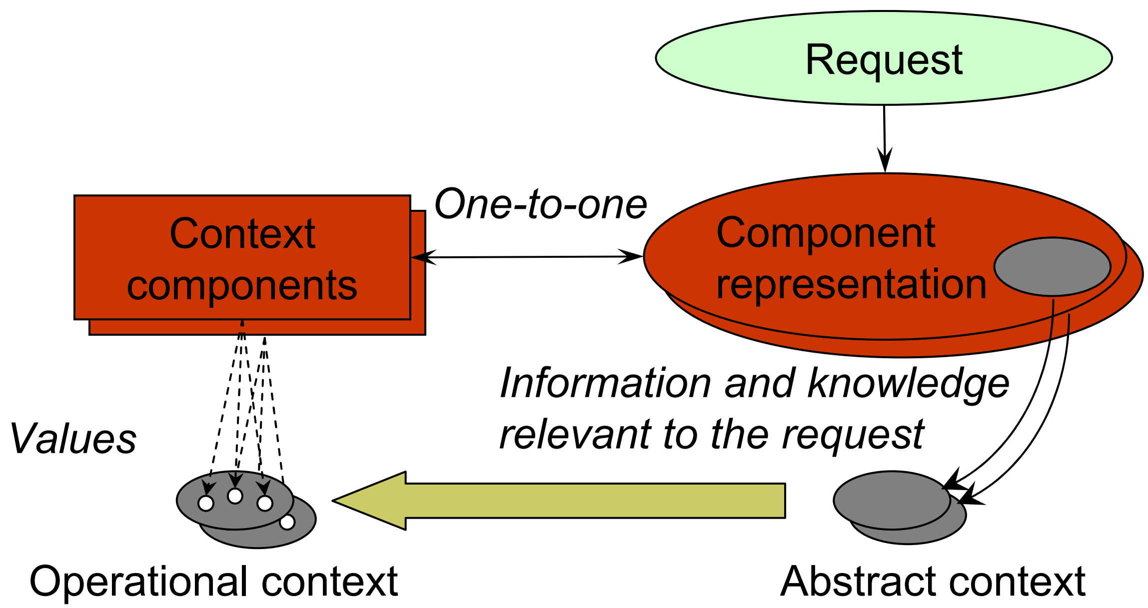
- Domain level
  - Integration of heterogeneous knowledge describing the domain knowledge
- Task level
  - Integration and formalization of tasks and problem-solving methods
- Context level
  - Integration of information and knowledge relevant to the problem or situation

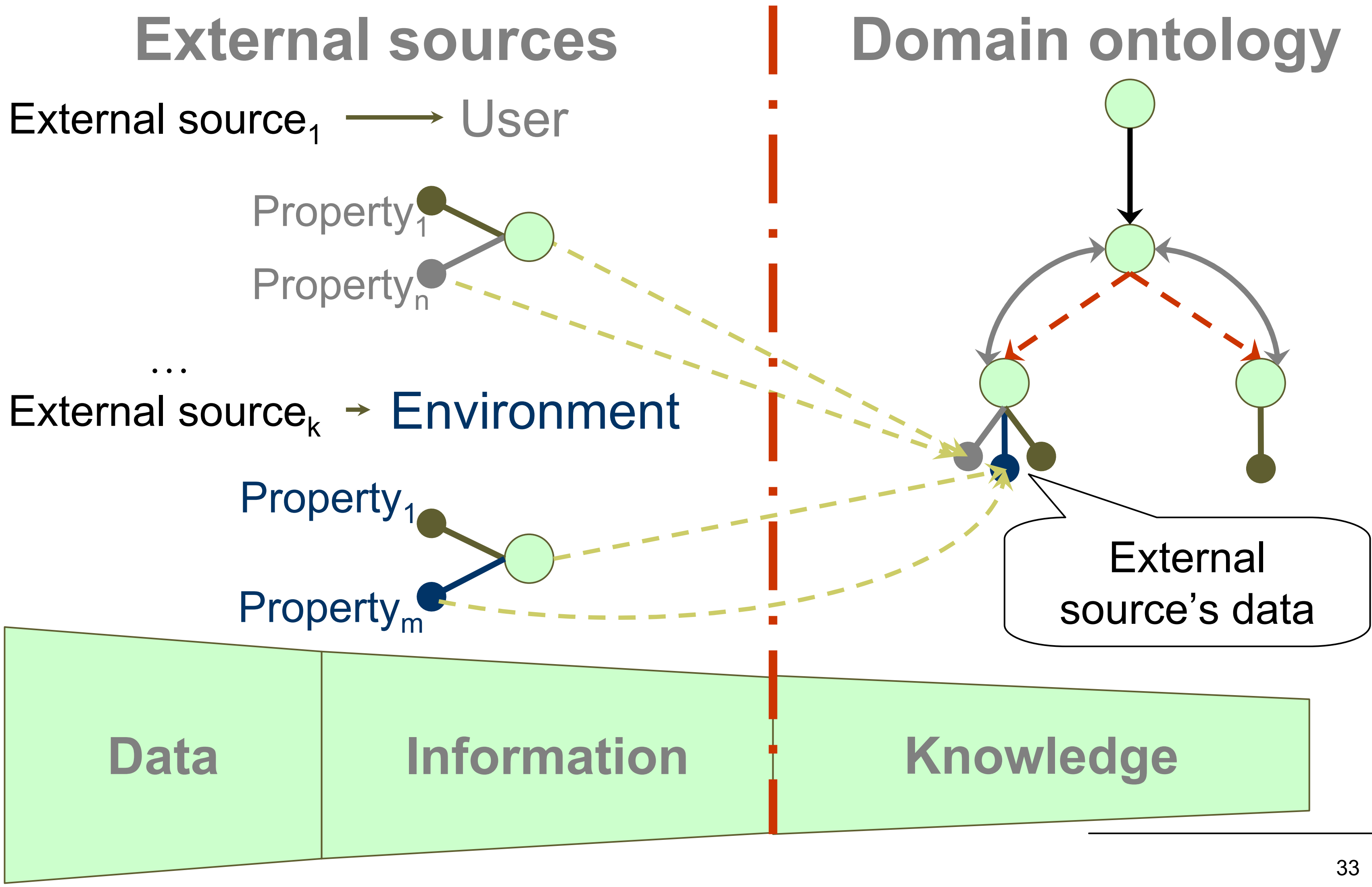
Context-Driven Methodology: Context Types

- **Abstract Context**
  information and knowledge relevant to the request provided by context components

- **Operational Context**
  instantiation of abstract context by values provided by context components included in the abstract context



Context-Driven Methodology: Relation to External Sources



Context-Driven Methodology: Simon's Model

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- "Intelligence phase" is defined as "searching the environment for conditions calling the decision" (Simon 65). The phase represents the start of the decision process. It involves the recognition of a problem which requires a decision, and gathering and an analysis of information concerning the problem.
- "Design phase" is described as "inventing, developing and analysing possible courses of actions" (Simon 65). This phase entails generation of alternative ways aimed at a goal achievement.
- In the "choice phase" all alternatives are searched, evaluated and one chosen as a recommended solution (Simon 65). This phase supports the operational level of decisions.

Resource: Simon H.A., *The Shape of Automation*. New York: Harper & Row, 1965.

Context-Driven Methodology: Simon's Model and Proposed Approach

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Simon's phase names	Intelligence	Design	Choice
Phase content	Problem recognition	Alternatives generation	Efficient alternatives selection
Steps	• fixing goals • setting goals	• designing alternatives	• evaluation & choosing alternatives
Proposed approach steps	**• abstract context composition** **• operational context producing**	**• constraint-based generating efficient alternatives**	

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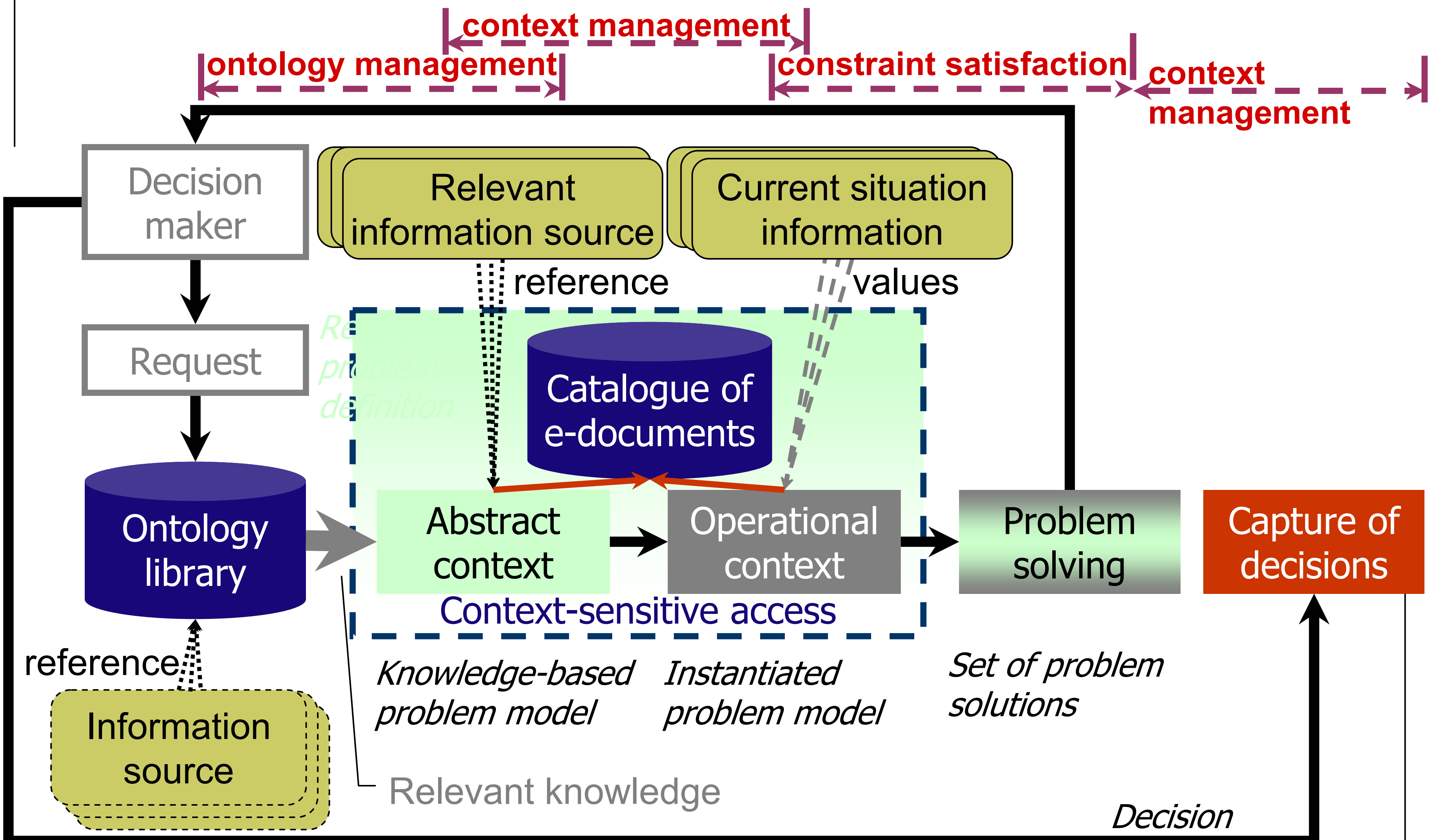
Context-Driven Methodology: Technological Framework



Context-Driven Methodology: Common Knowledge & Problem Representation Model

Ontology	Object-oriented constraint network (OOCN)	Constraint satisfaction problem
Class	Object (class)	A set of variables
Attribute	Variable	
Attribute range	Domain	Domain
Axioms and relations	Constraints	Constraints

Context-Driven Methodology: Ontology Representation Model

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- OOCN = (O, V, D, C)
  - O – a set of objects
  - V – a set of variables
  - D – a set of domains
  - C – a set of constraints

OOCN	Ontology Model
Set of objects	Class
Variable	Attribute
Domain	Attribute domain (range)
Set of constraints	Set of relations

- $C = C_1 \cup \ldots \cup C_6$
  - C_1: (class, attribute, domain) triple
  - C_2: hierarchical ("is-a", "part-of") relationships
  - C_3: classes compatibility
  - C_4: associative relationships
  - C_5: attribute cardinality restriction
  - C_6: functional relations

* Object-oriented constraint network

Context-Driven Methodology: Two-Stage Scenario

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Preliminary Stage

- Creation of models for components of DSS
- Linkage of domain knowledge and information sources

Decision Making Stage

- User request recognition
- Context-based problem modelling
- Constraint-based problem solving
- Decision making by the user
- Capture of decisions

Context-Driven Methodology: Models for Components of DSS

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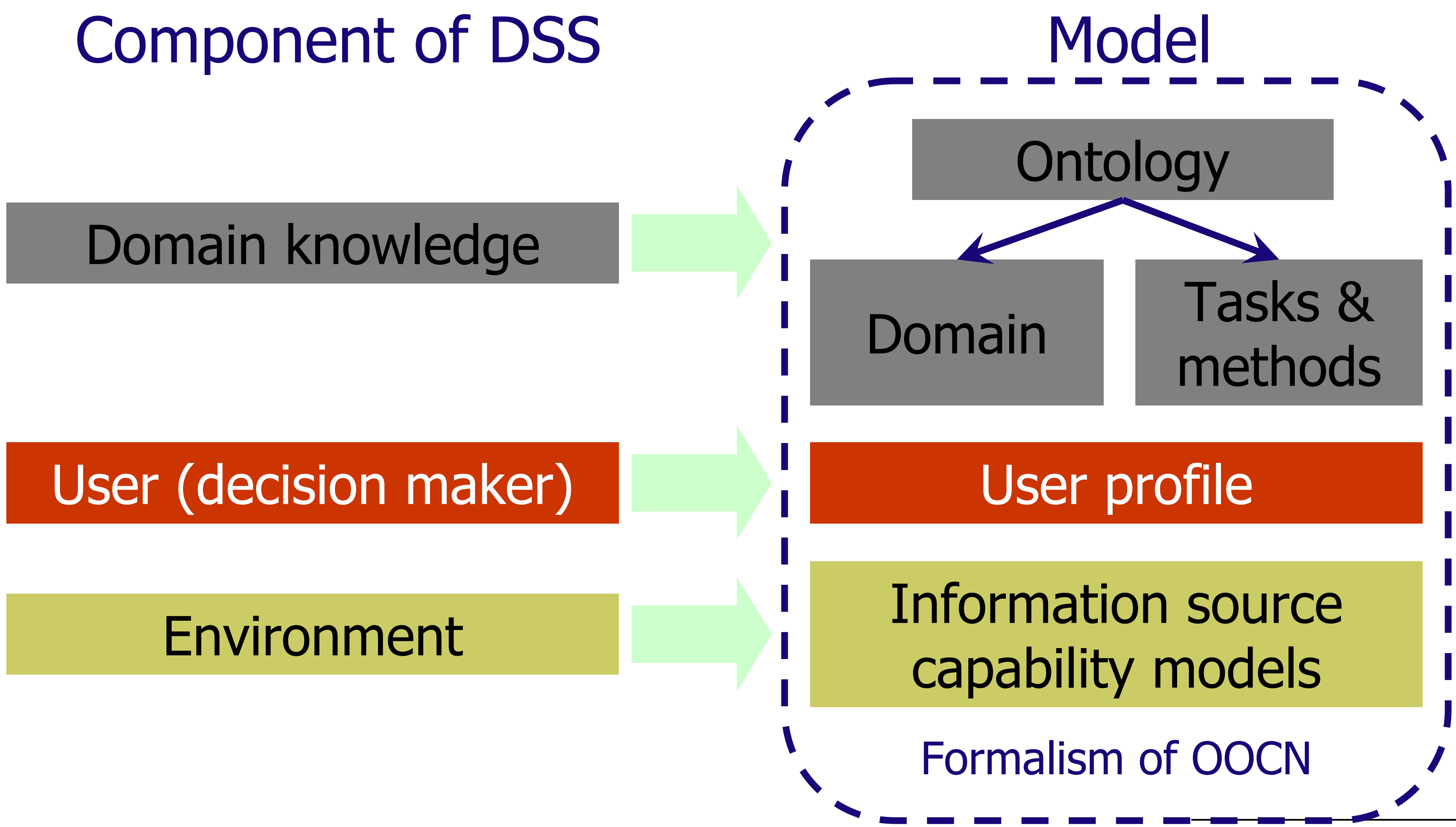

Context-Driven Methodology: Linkage of Domain Knowledge with Environment

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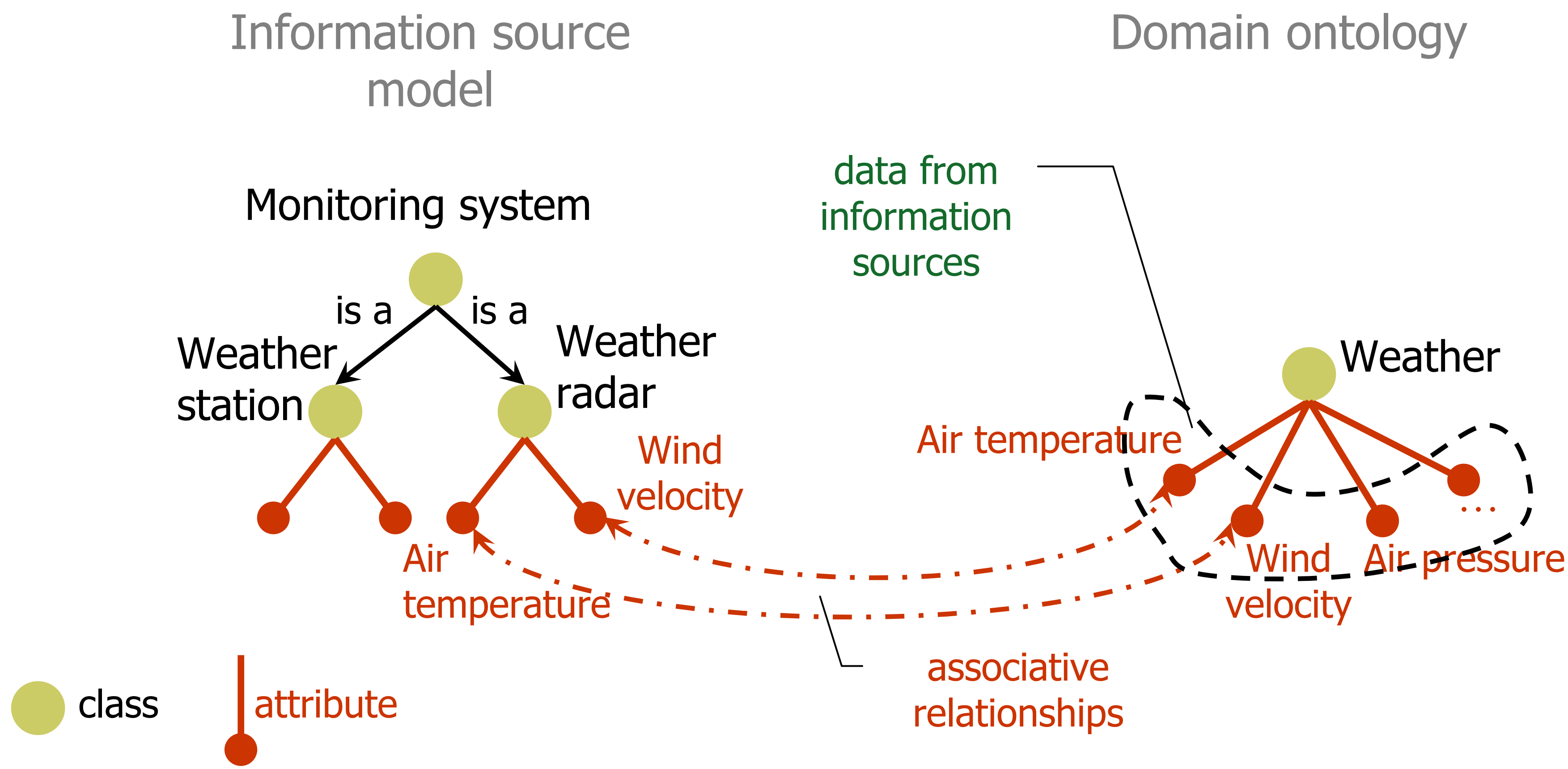
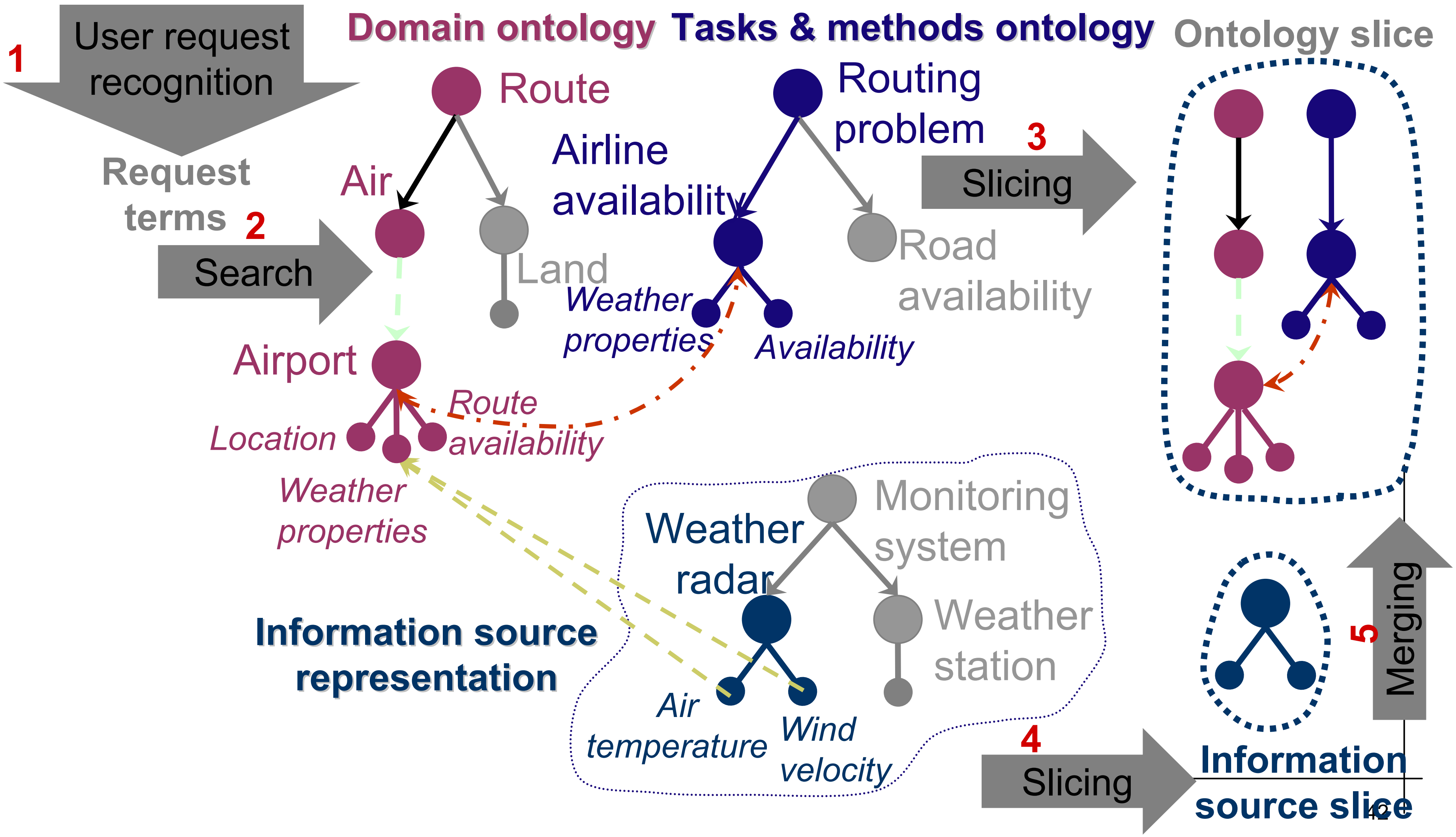


Context-Driven Methodology: Ontology-Based Integration of Information and Knowledge



Context-Driven Methodology: Constraint-Based Problem Modelling

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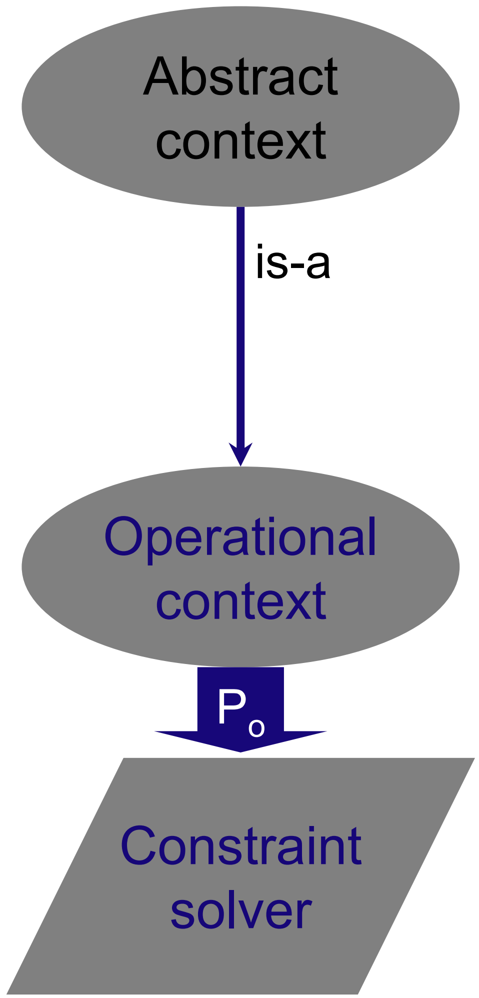
Constraint-based problem model

Constraint-based problem model with problem data

Constraint satisfaction problem



P_a = (O, A, D_o, C),

P – problem
modelled by abstract context
O – set of classes
A – set of class attributes
D_o – set of attribute domains defined in ontology slice
C – set of constraints

P_o = (O, A, D_i, C),

P – problem
modelled by operational context
D_i – set of attribute domains of size equal to data value provided by information sources

System “KSNet” Research Prototype: Integrated Framework

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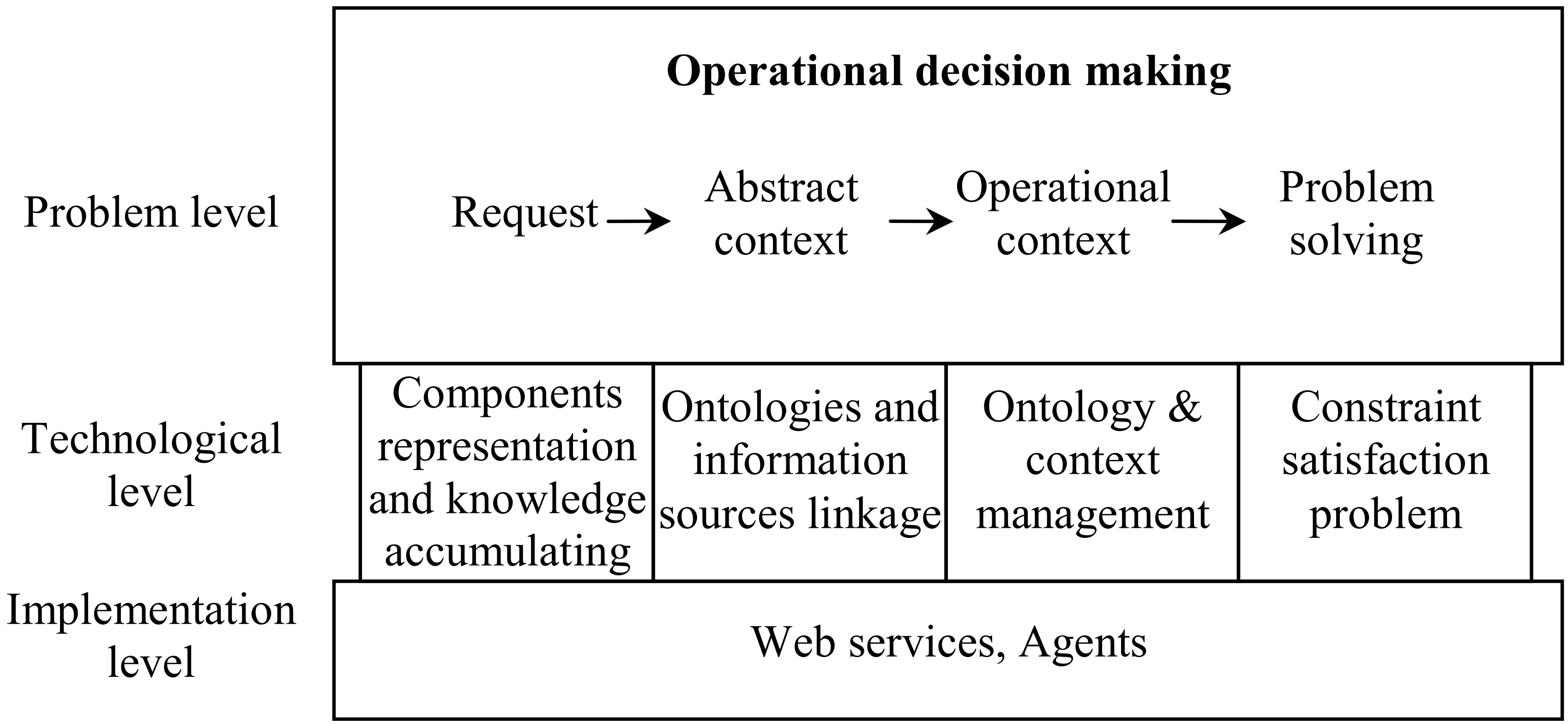

System “KSNet” Research Prototype: Adaptive Service

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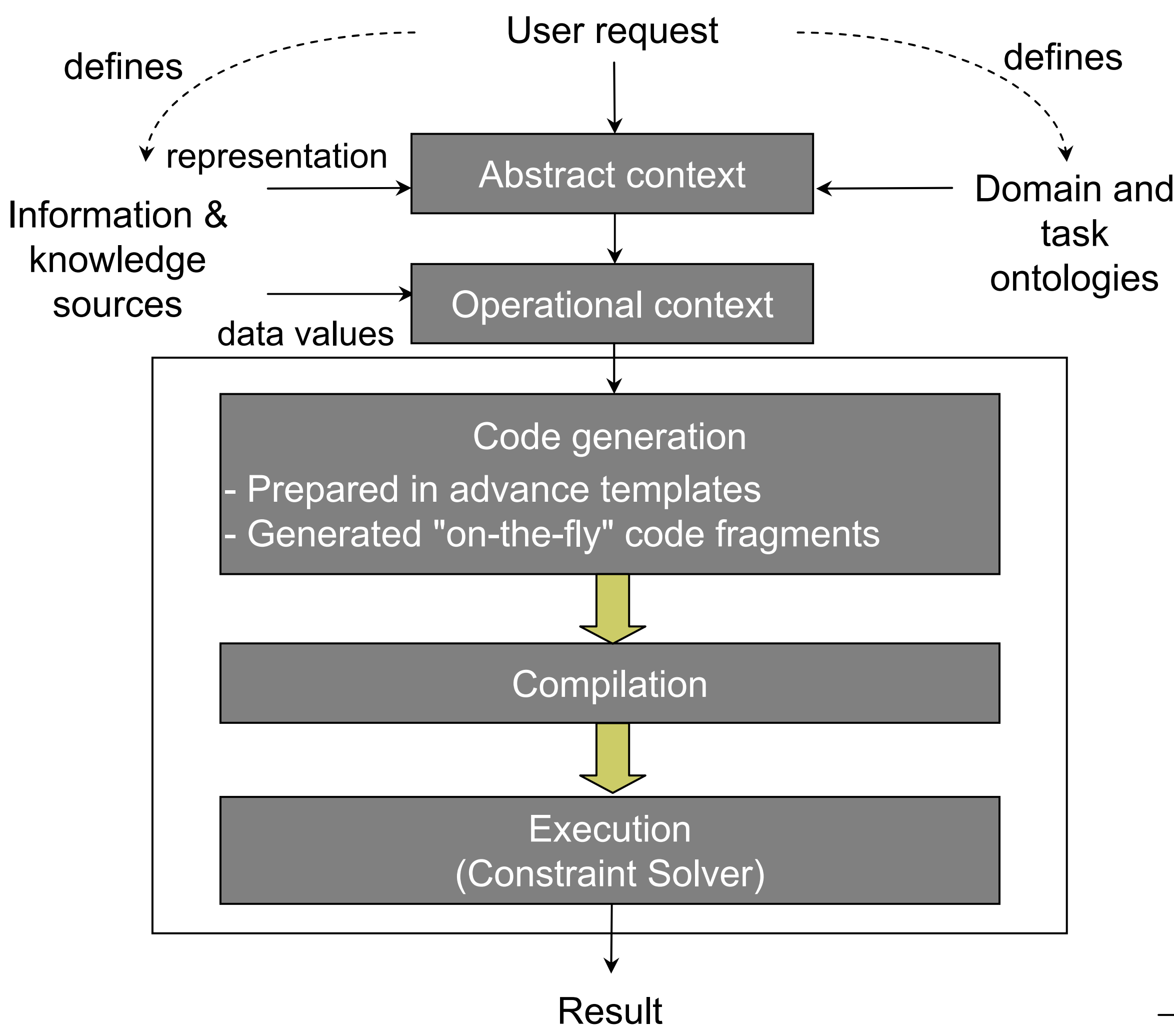

System "KSNet" Research Prototype:
Agent-Based Architecture

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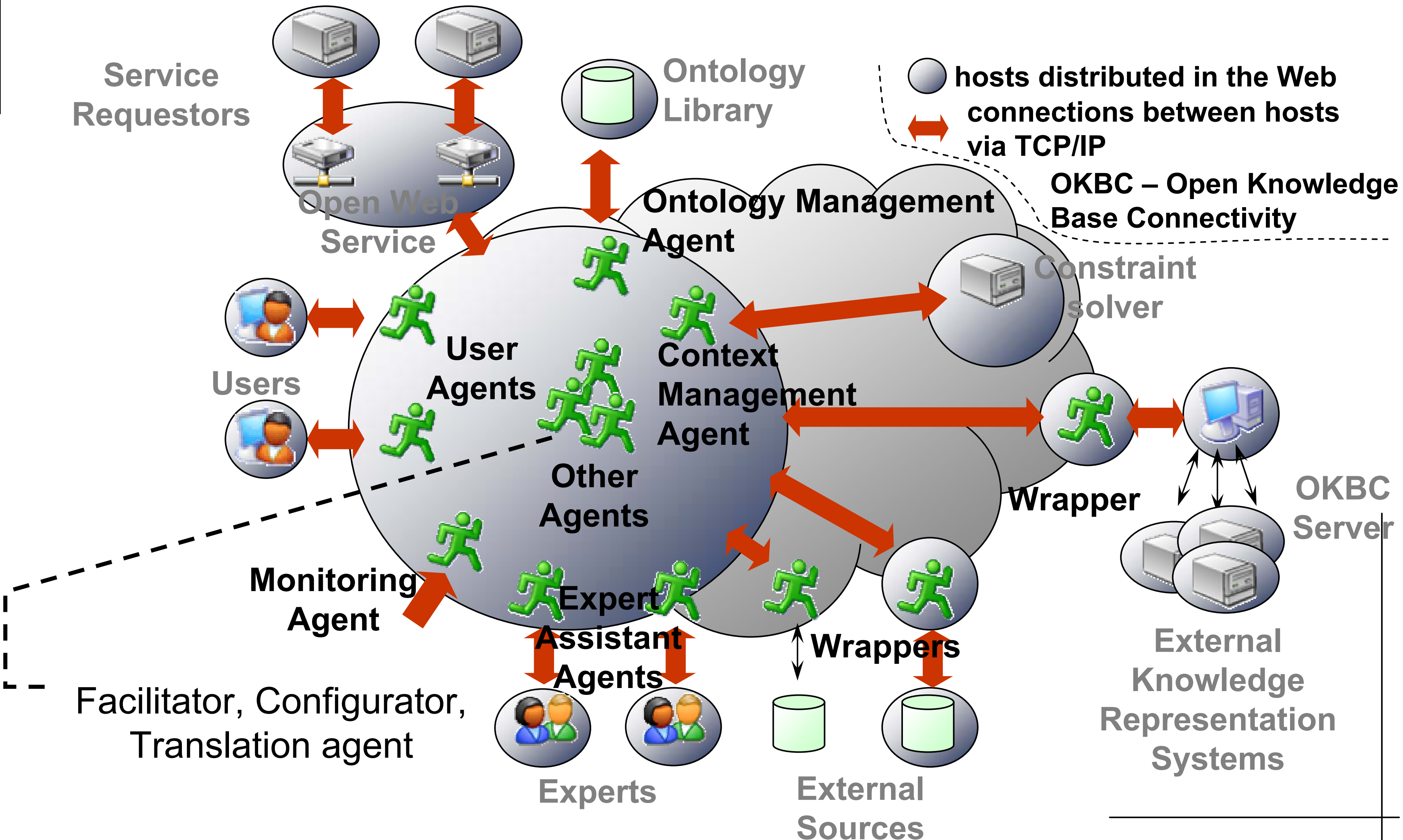

System “KSNet” Research Prototype: Agents Negotiation Protocol Choice Criteria

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- ***Contribution***: agents have to make the best contribution into the overall system's benefit – not into the agents' benefits
- ***Task performance***: the main goal is to complete the task – not to get profit out of it
- ***Mediating***: in all negotiation processes there is an agent managing the process and making a final decision
- ***Trust***: the agents can completely trust each other
- ***Common terms***: the agents use common terms for communication

System “KSNet” Research Prototype: Comparison of Negotiation Protocols

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Criteria	Protocols					
	VP	BP	AP	MMP	CGP	*CNP*
Task performance	☑	☑	☐	☐	☐/☑	☑
Contribution	☐/☑	☑	☐	☐	☐	☐/☑
Mediating	☐	☐	☑	☐	☐	☑
Trust	☑	☑	☑	☑	☐	☑
Common terms	☑	☑	☑	☑	☑	☑

☑ – **supported**

☐/☑ – **weakly supported**

☐ – **not supported**

Protocols:

- Voting (VP)
- Bargaining (BP)
- Auctions (AP)
- Coalition Games (CGP)
- General Equilibrium Market Mechanisms (MMP)
- **Contract Nets (CNP)**

System "KSNet" Research Prototype: Contract Net Protocol (CNP)

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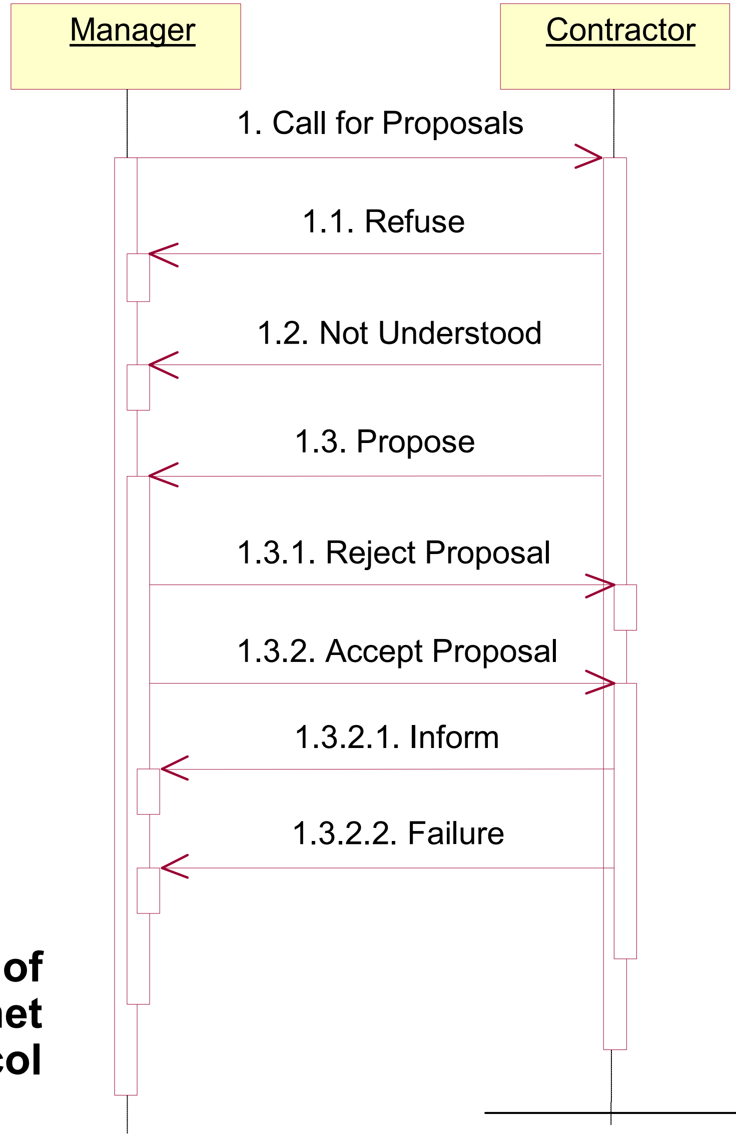
- More distributed negotiation than MMP
- The main features of this protocol are:
  1. *managers* (*initiators* in FIPA) divide tasks,
  2. *contractors* (*participants* in FIPA) bid,
  3. manager makes contract for lowest bid,
  4. there is no negotiation of bids.



UML sequence diagram of FIPA-based contract net protocol

System “KSNet” Research Prototype: Major Idea of Constraint-Based CNP

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- A generic call for proposals from a manager to contractors:

`Objective (optional) E.g. time→min`

`Constraints (optional) E.g. costs≤$20`

`Content (required)`

- A generic contractors’ proposal:

`Constraints (optional) E.g. costs=$15`

`Content (required)`

If contractors cannot meet the requirements of the manager they propose the closest possible parameters and manager decides whether to accept the proposal or not.

System "KSNet" Research Prototype: Constraint-Based CNP Schema

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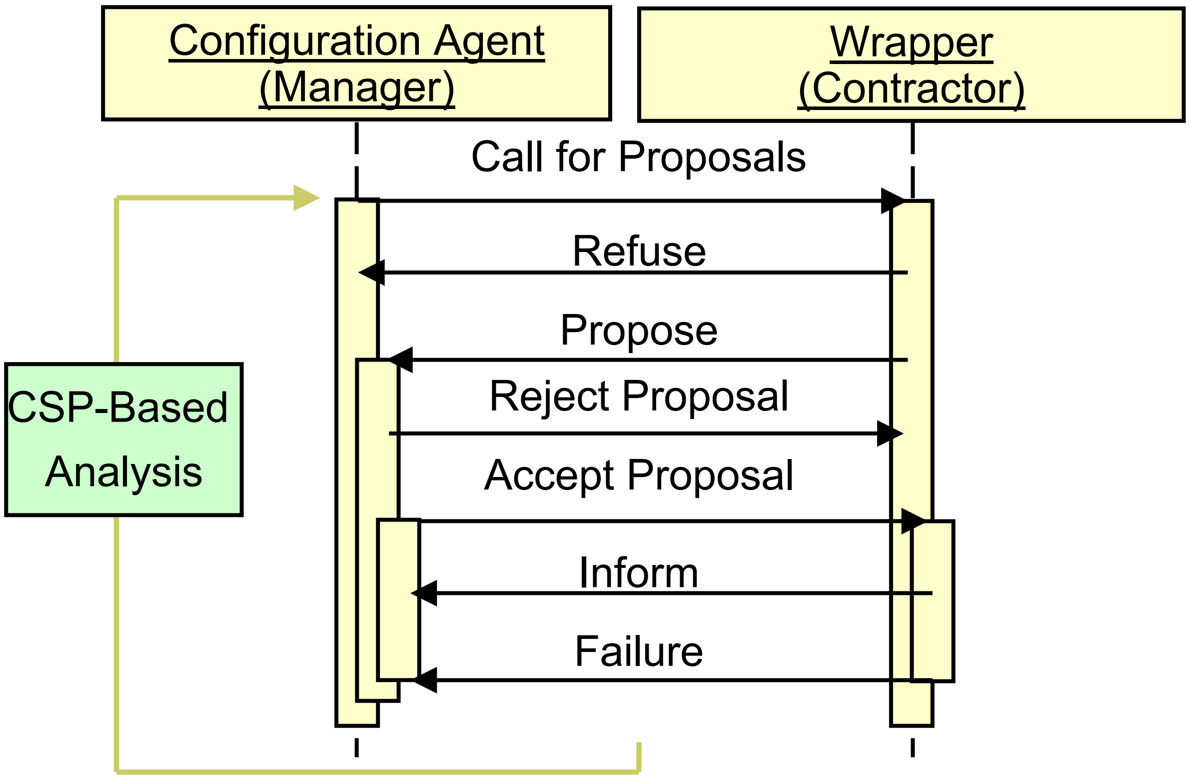

Here and then:

Yellow ( ) – conventional CNP

Green ( ) – modification

Given T_i=*1…n* – response time of contractors (*n* – is the number of participating contractors), $\mathrm{T}_{\mathrm{man}}$ – manager's response time, and T_C, T_M – negotiation time for conventional and modified constraint-based CNP respectively, $T_C \le T_M \le T_C + T_{max} + T_{man}$ holds, where $T_{max} = T_i$.

System “KSNet” Research Prototype: Experimentation with Constraint-Based CNP

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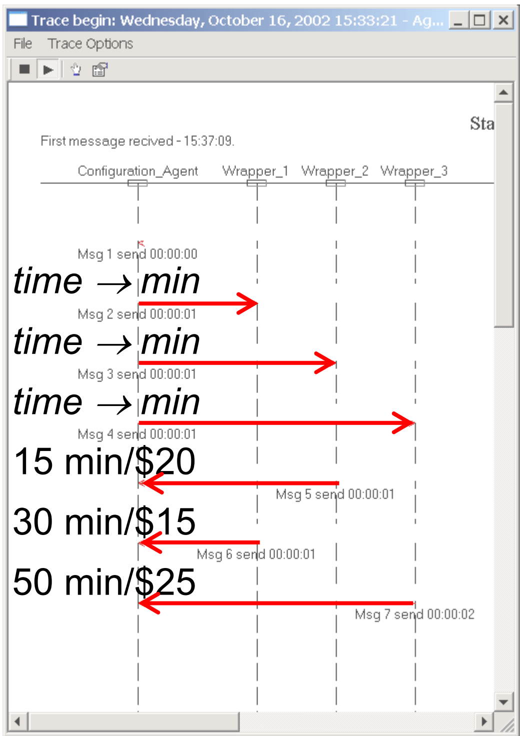
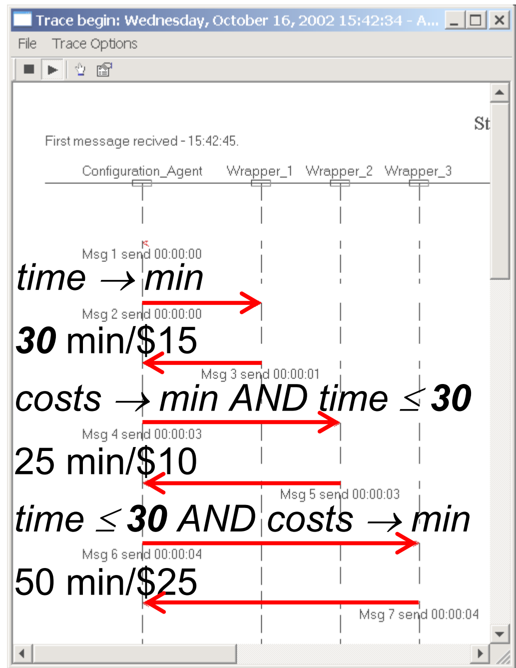
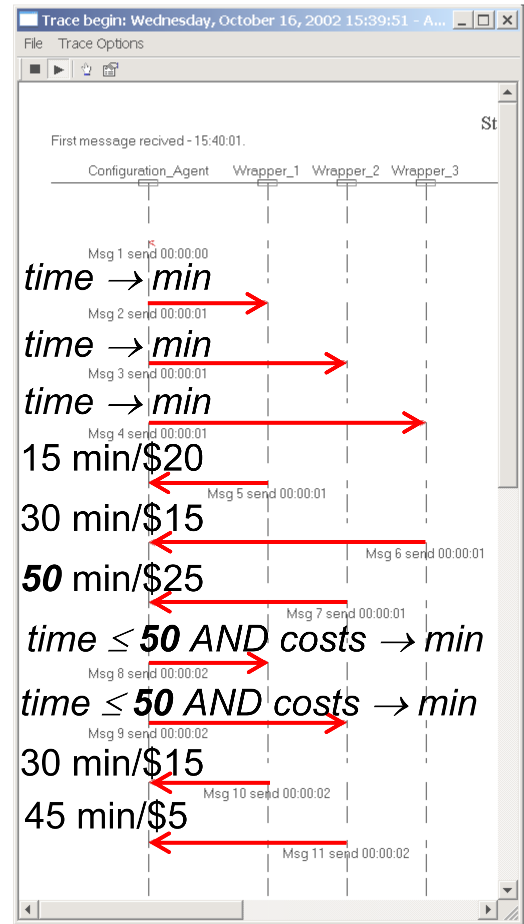
Conventional CNP	Sequential CNP	Constraint-Based CNP







50 min and $60	50 min and $50	50 min and $45

System "KSNet" Research Prototype: Comparison with Other Multiagent Systems (MAS)

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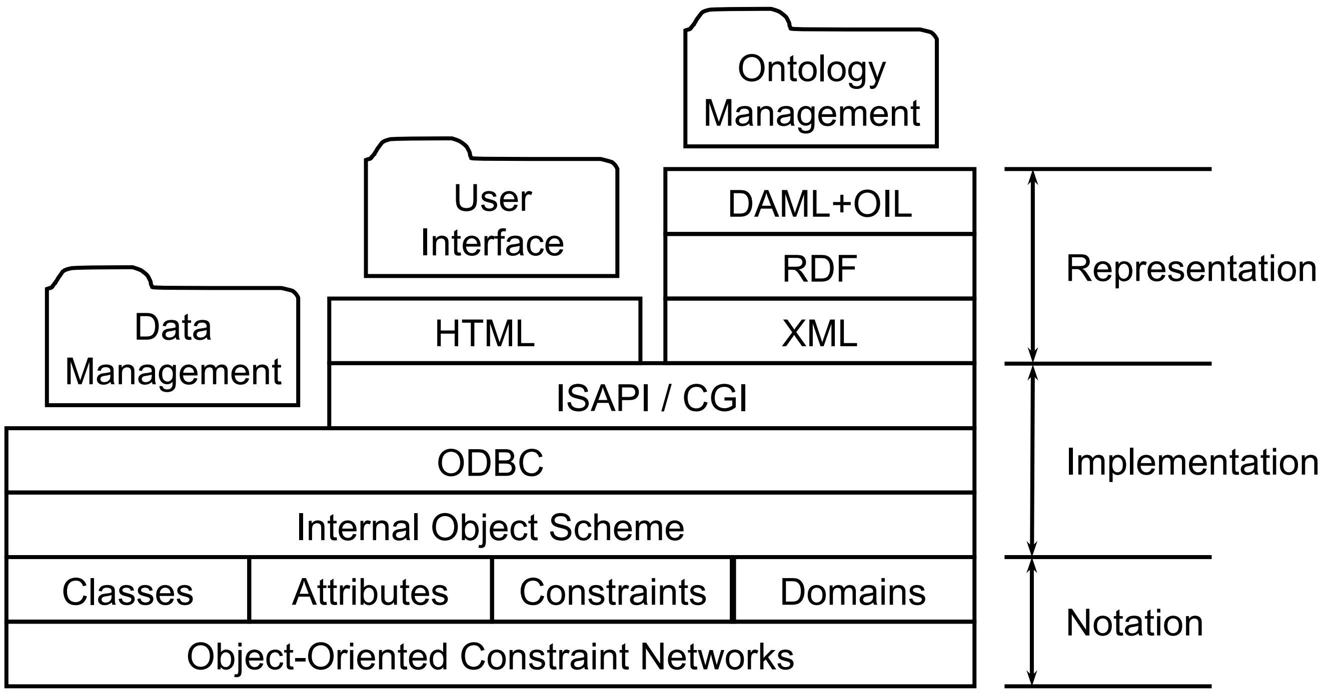
Project	KRAFT (UK)	OBSERVER (SPAIN)	InfoSleuth (USA)	KSNet (Russia)
Project Goal	MAS for information search under user defined constraints	System for synonymic relations based information search	Open MAS for information search	MAS for rapid Ontology-Driven Information Integration from distributed heterogeneous sources for Decision Making
Formats and Standards	KQML, P/FDM, CoLan, CIF	Internal formats	OKBC, LISP, CLISP, LDL+	OWL, DAML+OIL, KQML OOCN
Information about Users	N/A	Not supported	Requests history	User profiles, request ontologies
Base Ontologies	WordNet	Application (domain specific) ontologies	Application (domain specific) ontologies	Application (domain specific) ontologies
Ontologies organization	Hierarchy	Lattice	Meta-level ontology, Implicit hierarchy	Top-level ontology, taxonomy, hierarchy
MAS Architecture	FIPA-based with peer-to-peer interaction	Not supported	FIPA-based with mediating interaction	FIPA-based with peer-to-peer & mediating interaction

System “KSNet” Research Prototype: Standards of Information Kernel



DAML	– DARPA Agent Markup Language	HTML	– HyperText Markup Language
OIL	– Ontology Inference Layer	ISAPI	– Internet Server Application Programming Interface
RDF	– Resource Description Framework	CGI	– Common Gateway Interface
XML	– Extensible Markup Language	ODBC	– Open DataBase Connection

System “KSNet” Research Prototype: Standards of Service-Oriented Model

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		Semantics
Description and discovery	UDDI	Ontology
Service connection	WSDL	
Message protocol	SOAP	
Message syntax	XML	
Transport	HTTP	
	TCP/IP	

UDDI - Universal Description, Discovery, & Integration – a “meta service” for locating open services by enabling robust queries against rich metadata;

WSDL - Web Services Description Language – Interface Definition Language for open services;

SOAP - Simple Object Access Protocol – XML-based RPC protocol;

XML - Extensible Markup Language – a specification developed by the W3C for a pared-down version of SGML;

HTTP - HyperText Transfer Protocol – the underlying protocol used by the Internet;

TCP/IP - Transmission Control Protocol/Internet Protocol – the suite of communications protocols used to connect hosts on the Internet.

Case Study: Humanitarian Logistics

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- The number of annual natural and human-made disasters has tripled since 1970. The strains on humanitarian organizations responding to emergencies showed that in last year 256 million people were reported affected by disasters, while the annual average is 210 million. The practice shows that one of the most difficult steps is getting the right relief supplies to the people in need at the right time. At the same time delivering of too much supplies or wrong supplies means loosing time and money. Therefore, humanitarian logistics standing for *processes and systems involved in mobilizing people, resources, skills and knowledge to help vulnerable people affected by natural disasters and complex emergencies*, is central for disaster relief

Source: Humanitarian Logistics: Getting the Right Relief to the Right People at the Right Time, Fact Sheets, Fritz Institute, 2005 URL: http://www.fritzinstitute.org/-fact_sheets/-f_s-hls.html.

Case Study: Requested Information

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- Hospital related information (structure, components, times of delivery)
- Available United Nations and friendly suppliers (suppliers' capabilities, capacities, locations)
- Available United Nations and friendly providers of transportation services (available types, routes, and time of delivery)
- Geography and weather of the Binni region (types, routes, and time of delivery in dependence on a method of delivery, e.g. by air, by trucks, by off-road vehicles)
- Political situation, e.g. who occupies used for transportation territory, existence of military actions on the routes, etc. (additional constraints on routes of delivery)

Case Study: Ontology Creation

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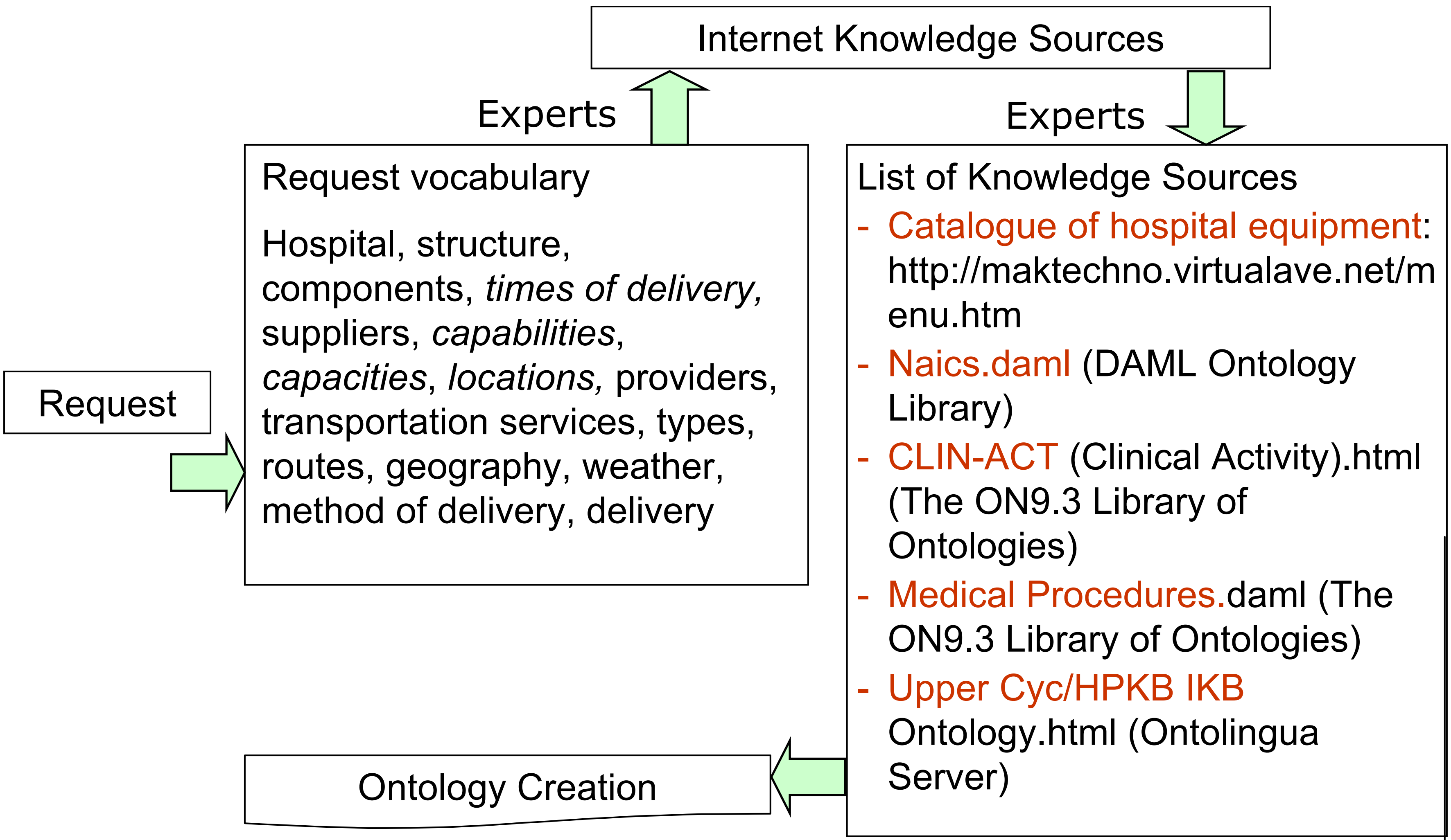

Case Study: Complex of Tasks

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- **Treatment Course Definition**
  - find the right treatment course for the given injury type
- **Hospital allocation**
  - find the most appropriate location for a portable hospital considering locations of the disaster, water resources, nearby cities and towns, communication facilities (e.g., locations of airports, roads, etc.), etc.
- **Resource allocation**
  - find the most efficient hospital configuration considering type and quantity of material or goods required for the hospital, properties (location, costs, productivity, availability, etc.) of suppliers of the materials and goods, optimization parameters (costs or time)
- **Routing problem**
  - find the most efficient ways of delivery of the hospital's components from available suppliers considering communications facilities (e.g., locations of airports, roads, etc.), their conditions (e.g., good, damaged or destroyed roads), weather conditions (e.g., rains, storms, etc.)

Case Study: Tasks & Methods Ontology

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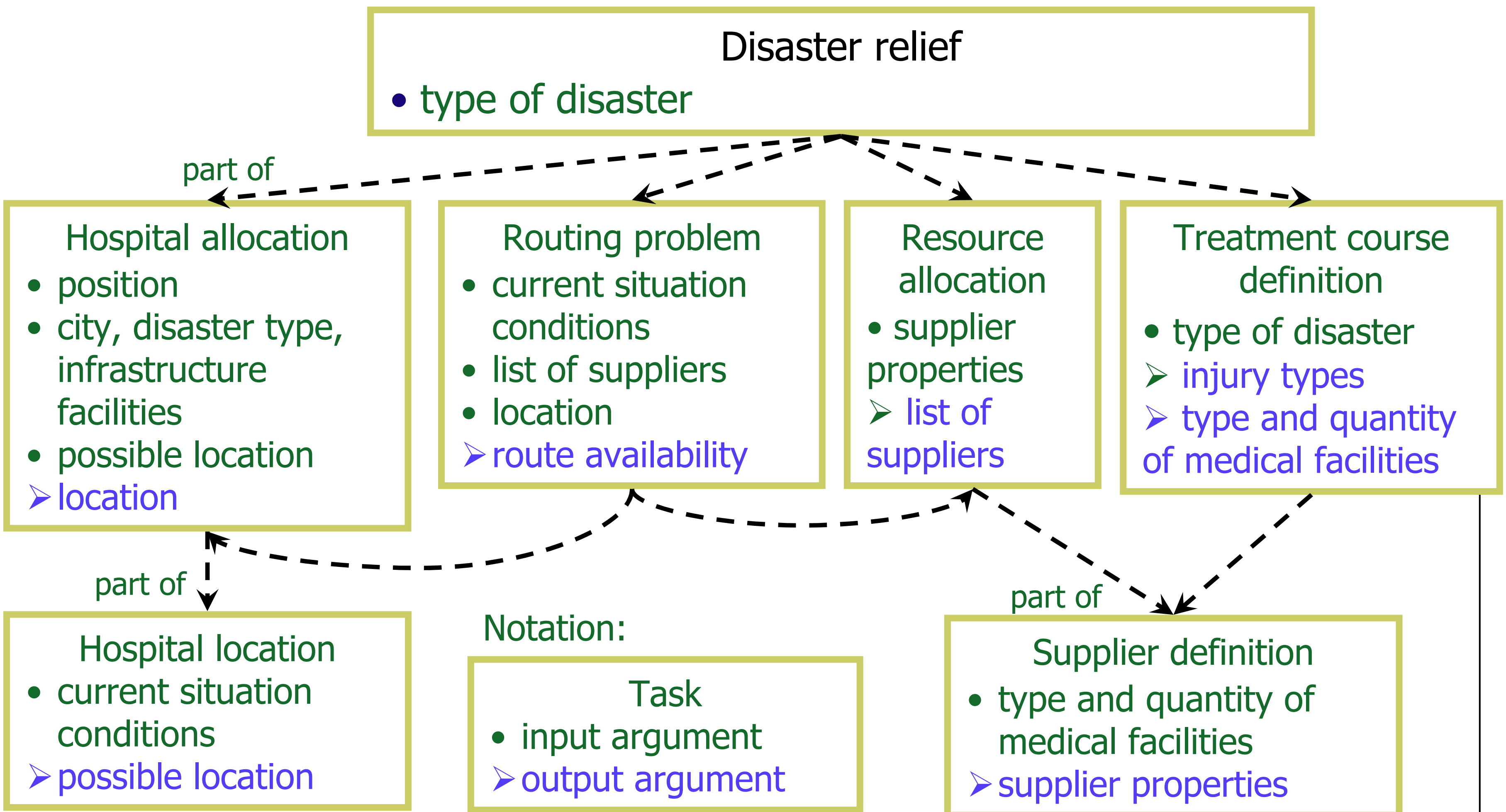
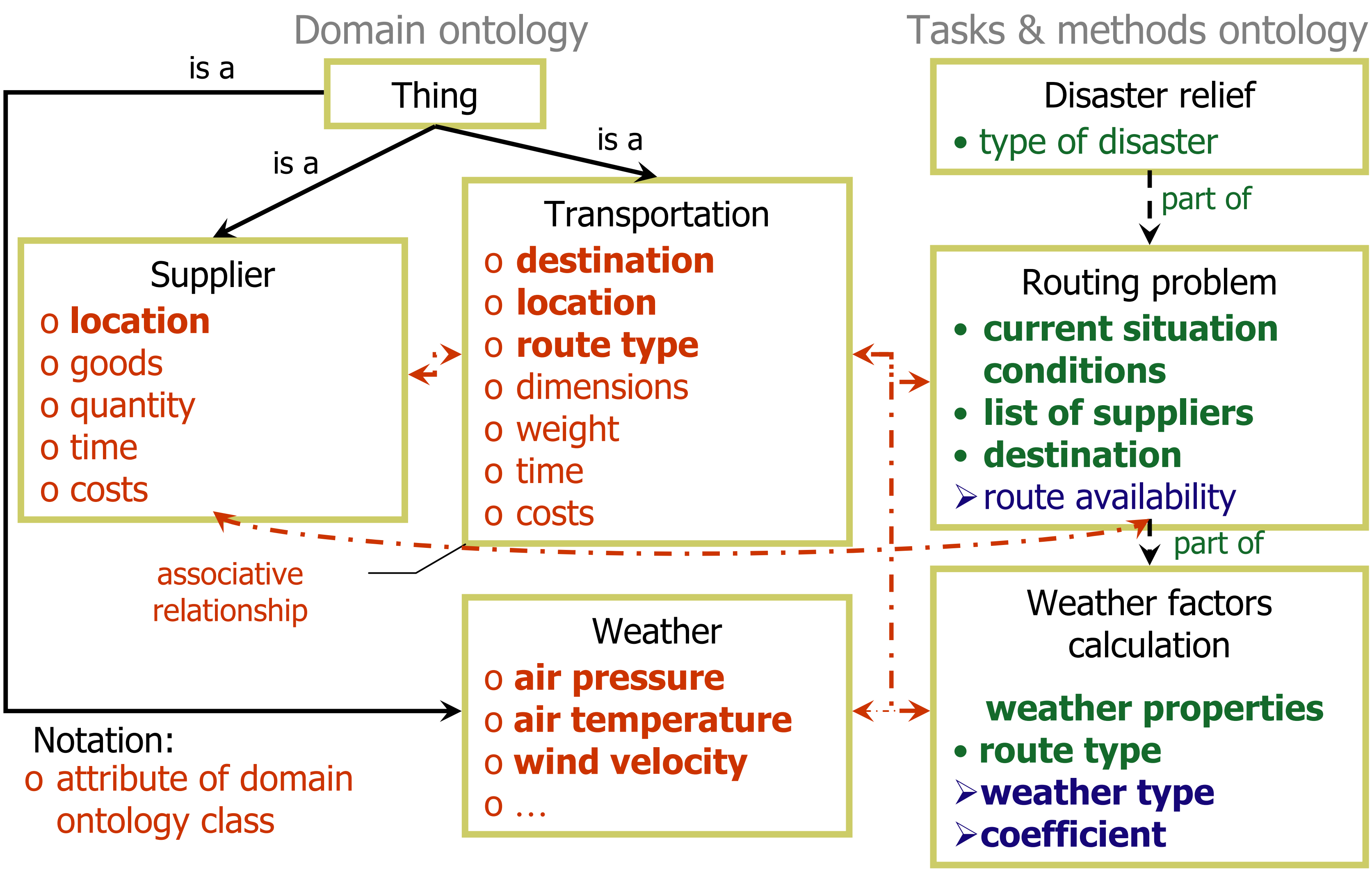


Case Study: Interactions between Domain and Tasks & Methods Ontologies



Case Study: Domain Ontology Slice for “Hospital Allocation” Task

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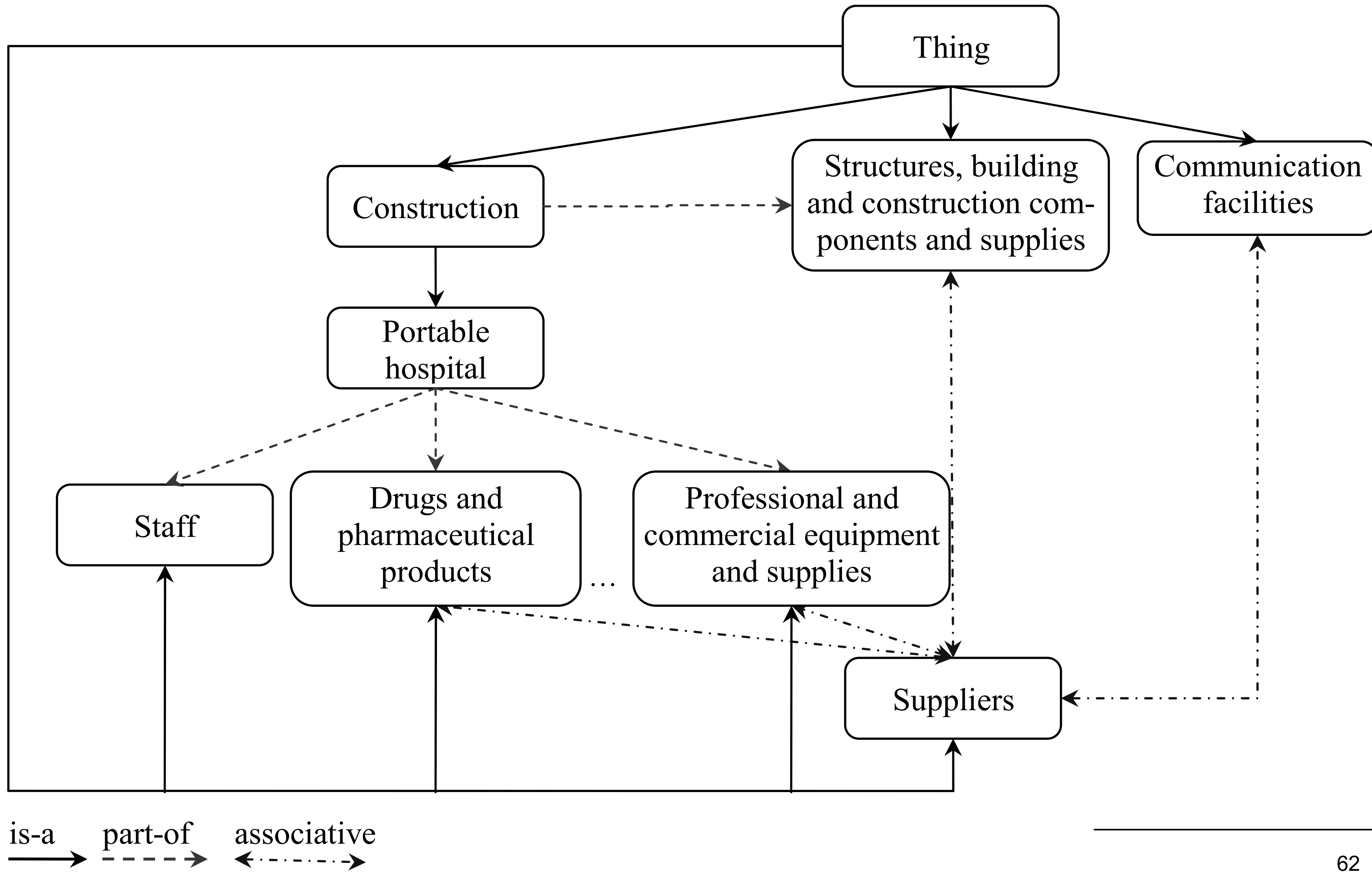
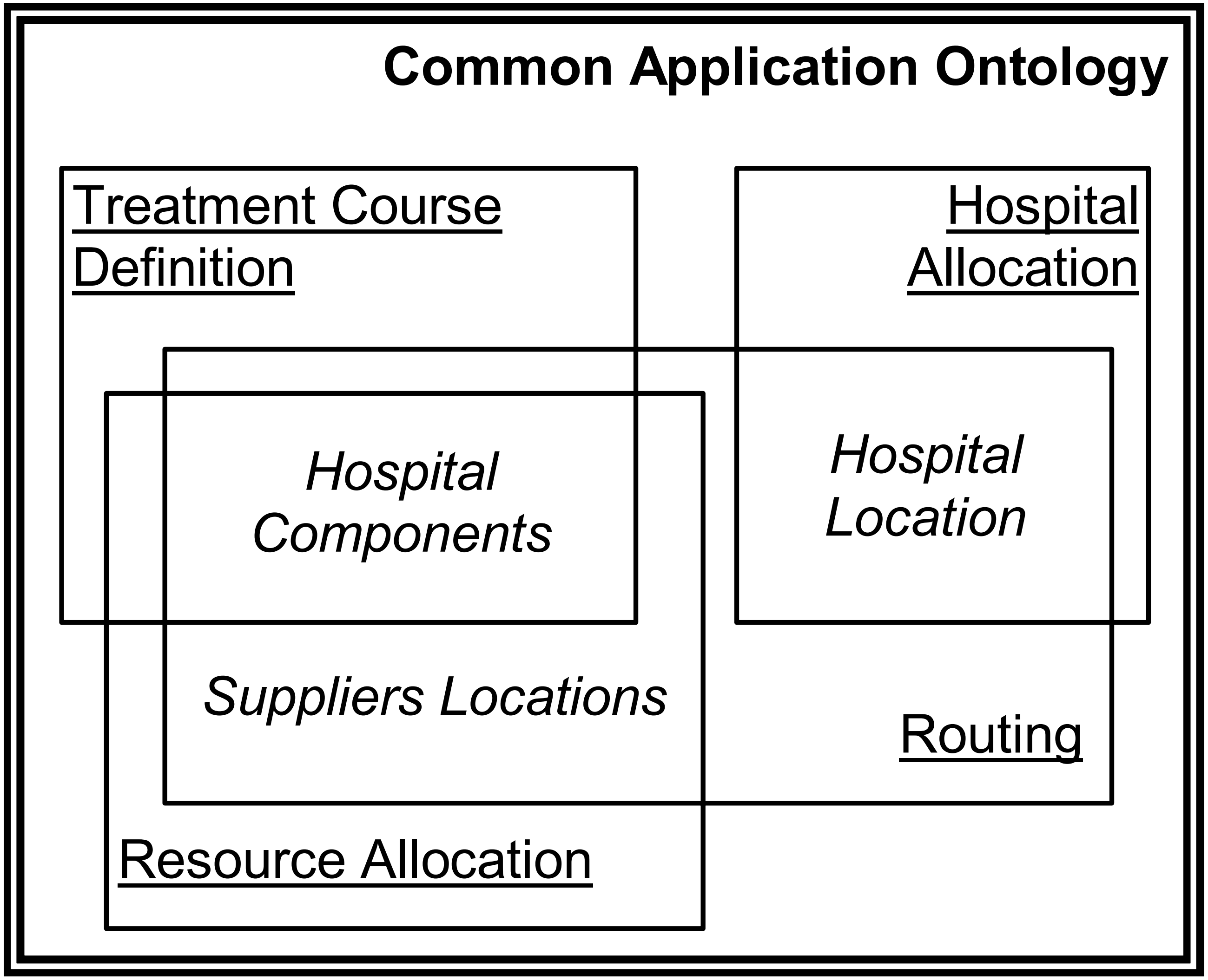


Case Study: Common Application Ontology



<u>Hospital Allocation – Task;</u> Hospital Location - Ontology Element

Case Study: Application Ontology Fragment

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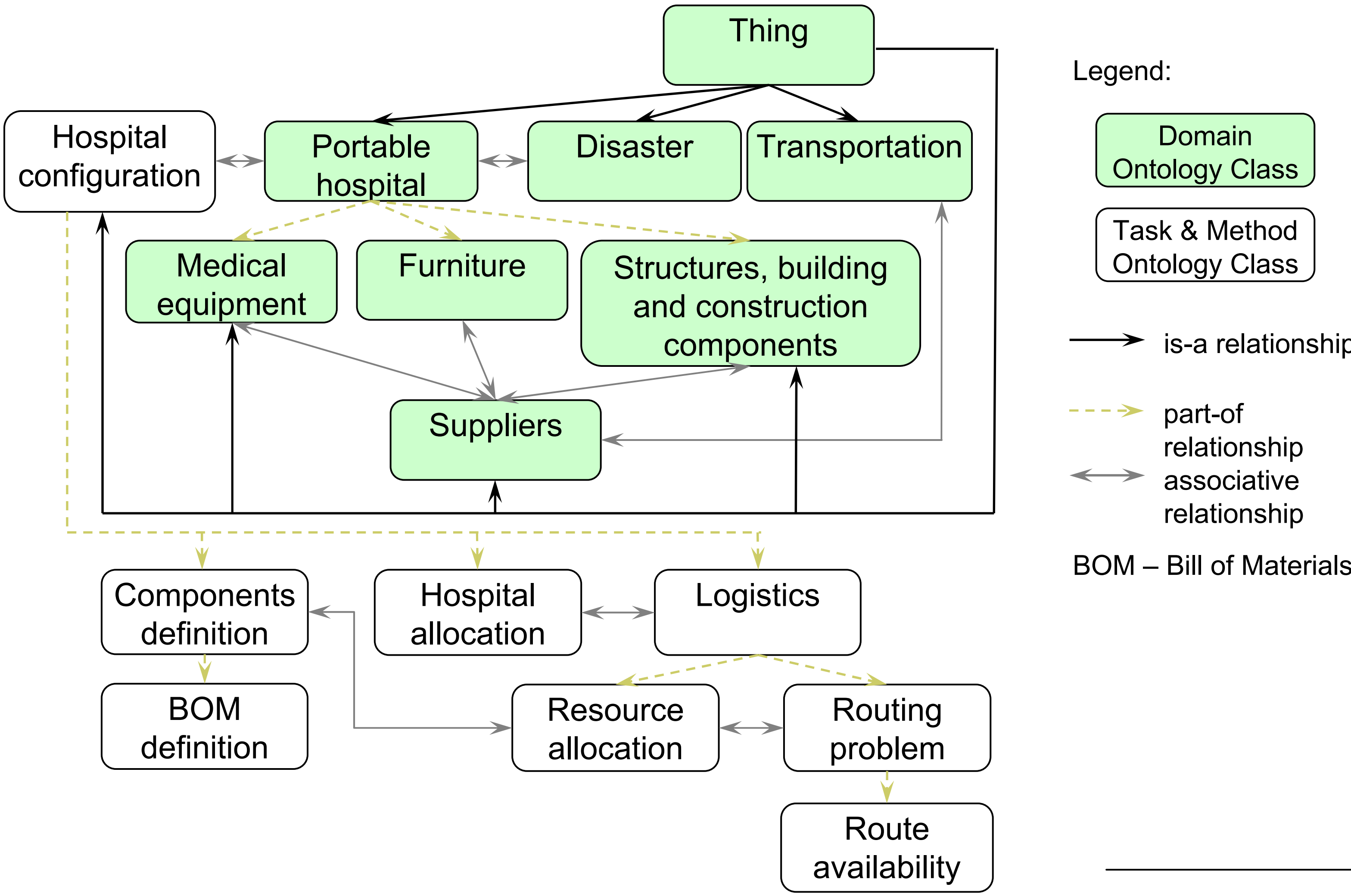

BOM – Bill of Materials

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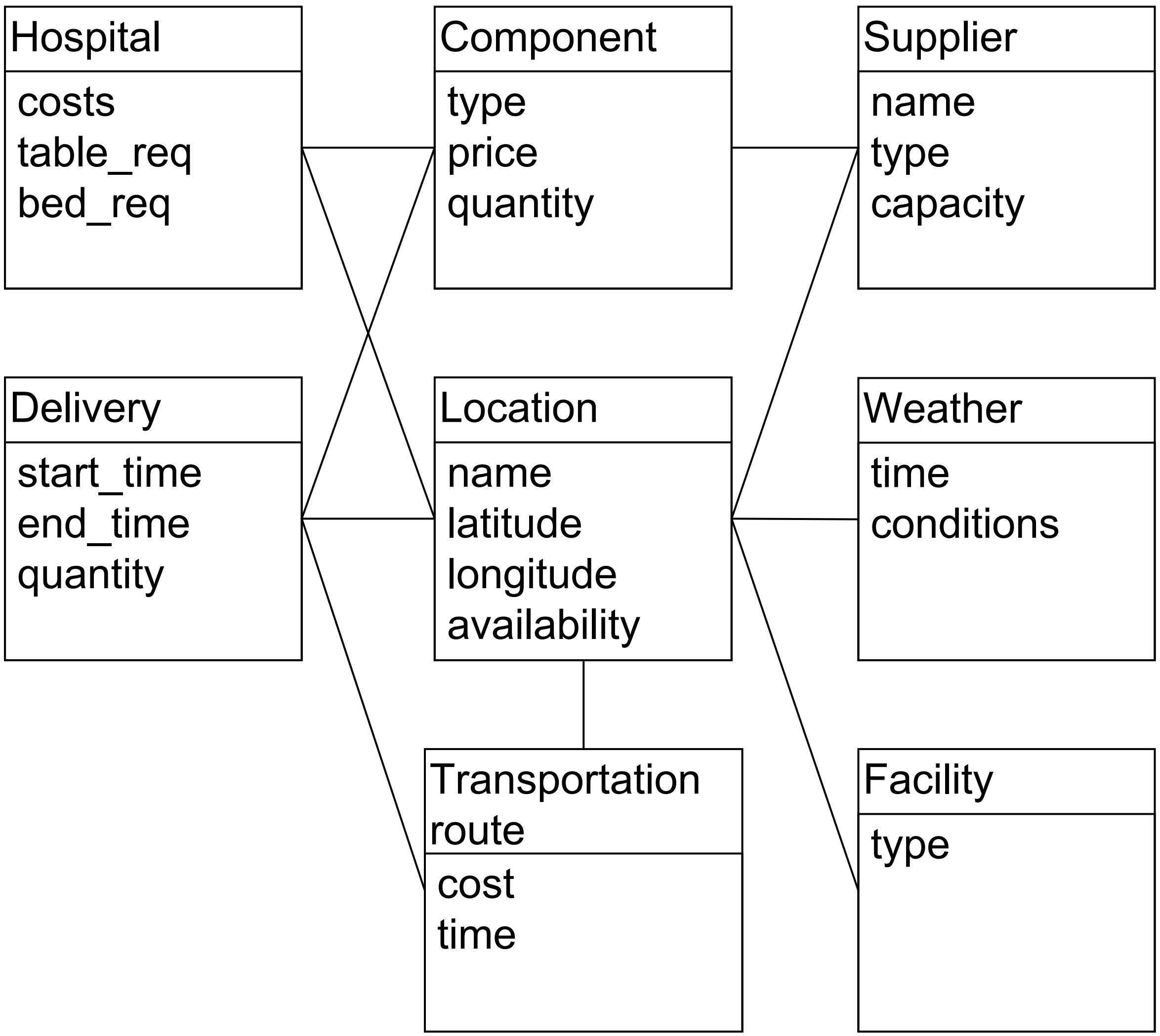
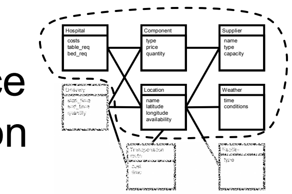
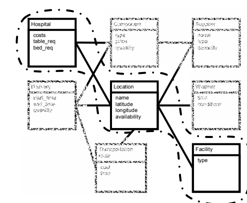
Case Study: Abstract Context Example



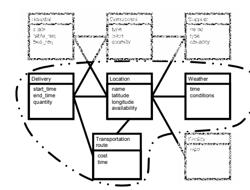
Resource Allocation



Hospital Allocation



Routing



Case Study: Operational Context Example

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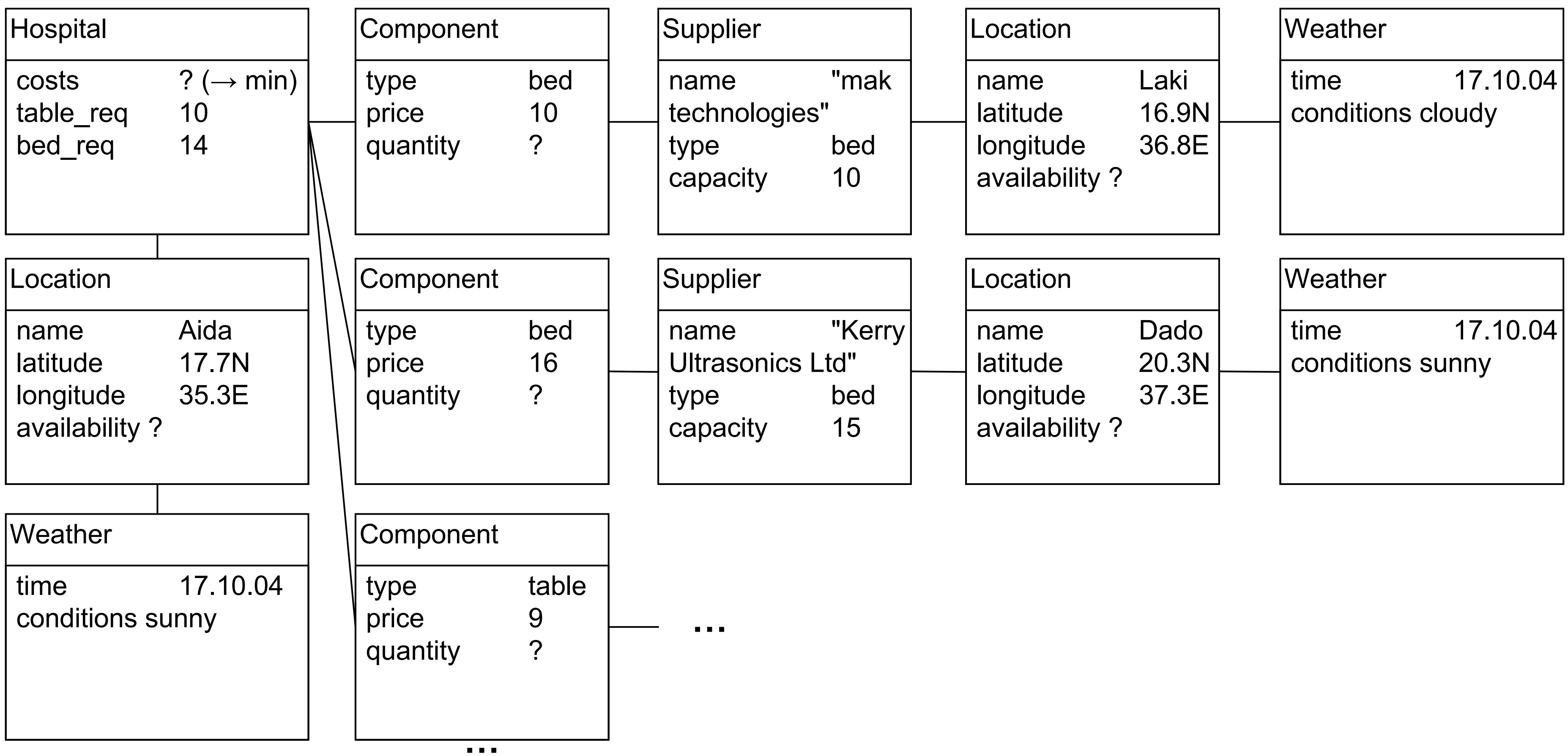

Case Study: Examples of Constraints

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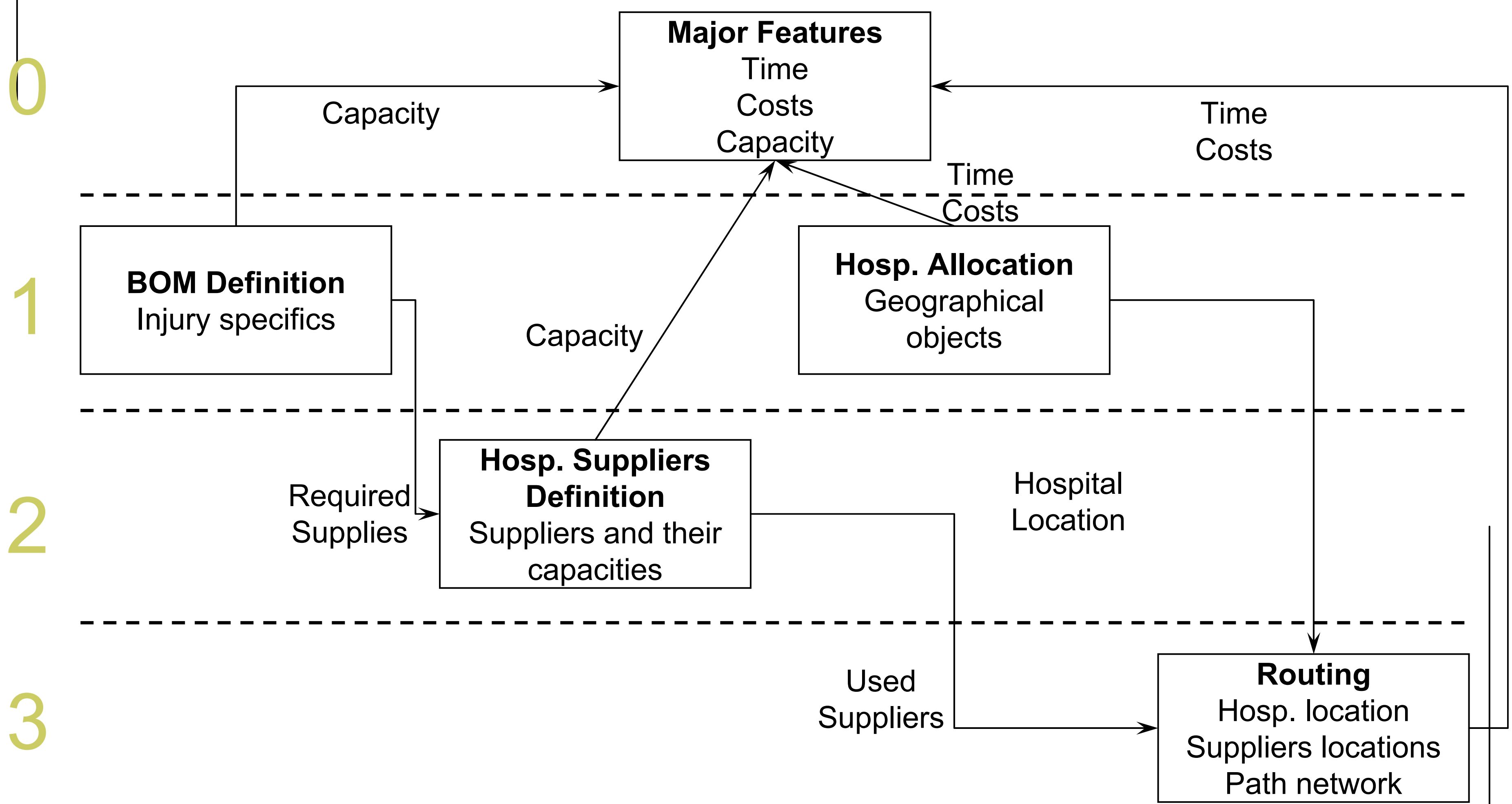
- the attribute *costs* (*q*1) belongs to the class *hospital* (*o*1): *cI*1 = (*o*1, *q*1);
- the attribute *costs* (*q*1) belonging to the class *hospital* (*o*1) takes positive values: *cII*1 = (*o*1, *q*1, R+);
- *mobile hospital* (*o*5) is a *hospital* (*o*1): *cIV*1 = ⟨*o*1, *o*5, 0⟩;
- the class *medical equipment* (*o*4) is a part of the class *hospital* (*o*1): *cIV*1 = ⟨*o*1, *o*4, 1⟩;
- the class *furniture* (*o*2) is compatible with the class *furniture supplier* (*o*3): *cIII*1 = ({*o*2, *o*3}, *True*);
- the attribute *capacity* of the class *mobile hospital* (*o*5) serves as an input parameter in the class *components definition* (*o*6): *cV*1 = (*o*5, *o*6);
- the value of the attribute *cost* (*q*1) of an instance of the class *furniture* (*o*2) depends on the values of the attribute *price* (*q*2) of instances of the class *suppliers* (*o*6) and on the number of such instances (the attribute *quantity* (*q*3) of the class *furniture*): *cVI*1 = *f*({*o*2, *q*1}, {(*o*6, *q*2), (*o*2, *q*3)});

Case Study:
Hospital Configuration Problem



Case Study:
Example Result of User Request Processing

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Result - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites Media

Address http://localhost/ksnet/templates/hospital_result.php?id_request=363&id=1021595177111830 Go Links

Result

Supplier: **mak technologies**

Type	Quantity	Cost	Delivery Time	Route description	Photo
Hospital Bed	10	100	6	highway	

Supplier: **Kerry Ultrasonics Ltd**

Type	Quantity	Cost	Delivery Time	Route description	Photo
Hospital Bed	4	64	6	highway	

Supplier: **OPTIWAY TECHNOLOGY INC**

Type	Quantity	Cost	Delivery Time	Route description	Photo
Operating Table	7	63	6	highway	

Done Local intranet

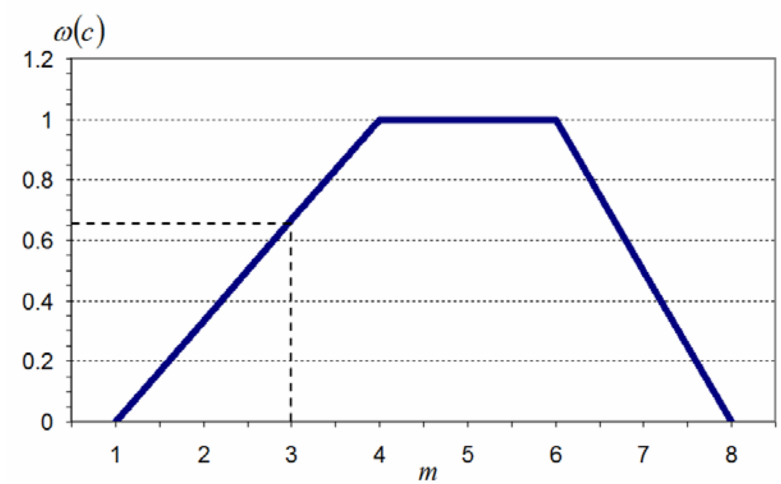
Case Study: Uncertainty Treating Example

- Number of operating tables per patient:
  - Experts' estimations (min; max): [2; 8], [4; 6], [1; 7], [3; 6], [4; 8], [2; 7], [3; 7]
- Influence:
  - If only 3 tables are considered the decision's reliability is 66.67%

$$\omega(c)=\begin{cases} 0, m\le 1; m\ge 8 \\ \dfrac{m-1}{3}, 1<m<4 \\ 1, 4\le m\le 8 \\ \dfrac{8-m}{2}, 6<m<8 \end{cases}, \text{ where}$$

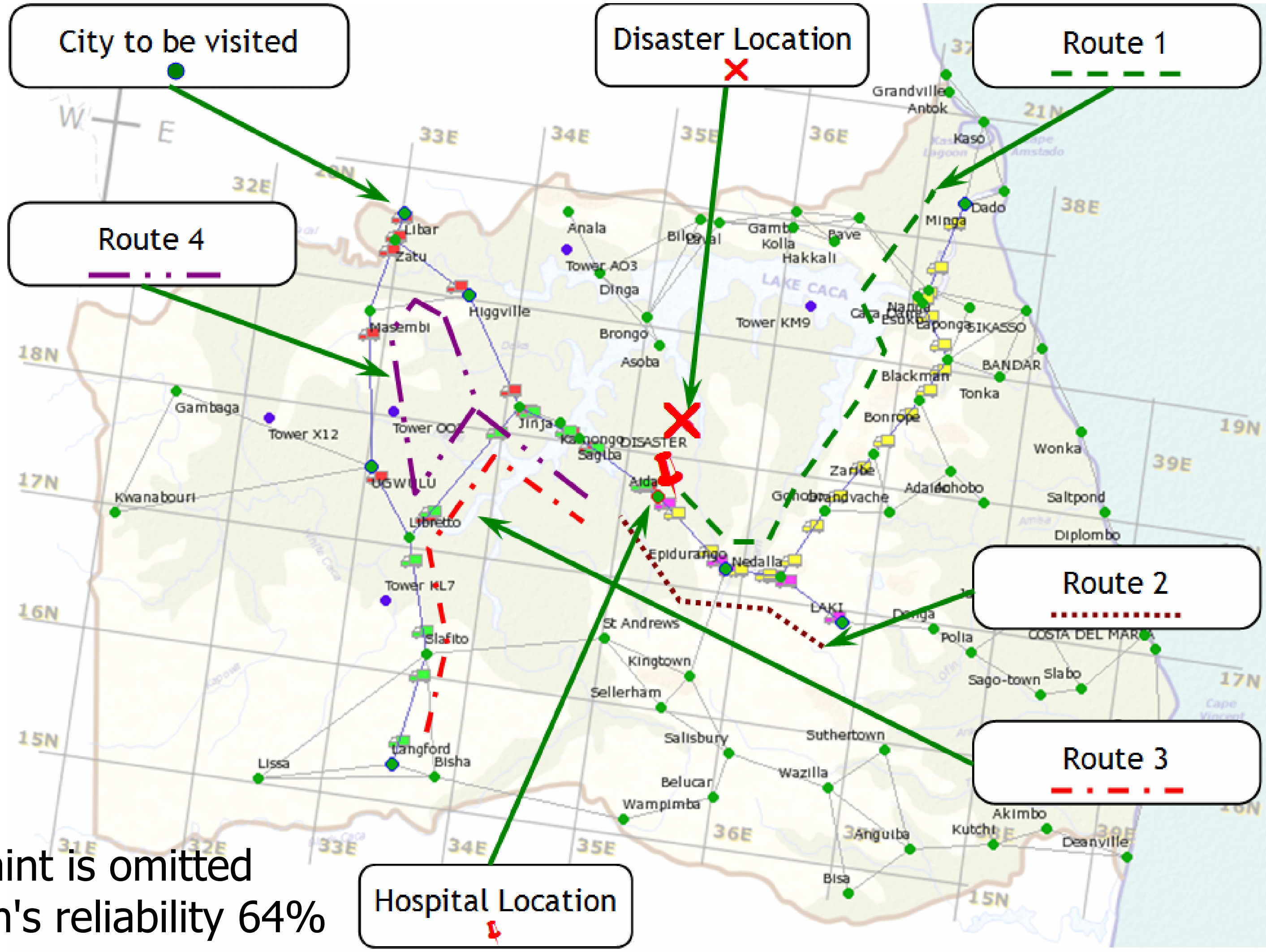
$\omega(c)$ – fuzzy value of the constraint,

m – number of operating tables per 50 patients.



Case Study:
Example Result of User Request Processing

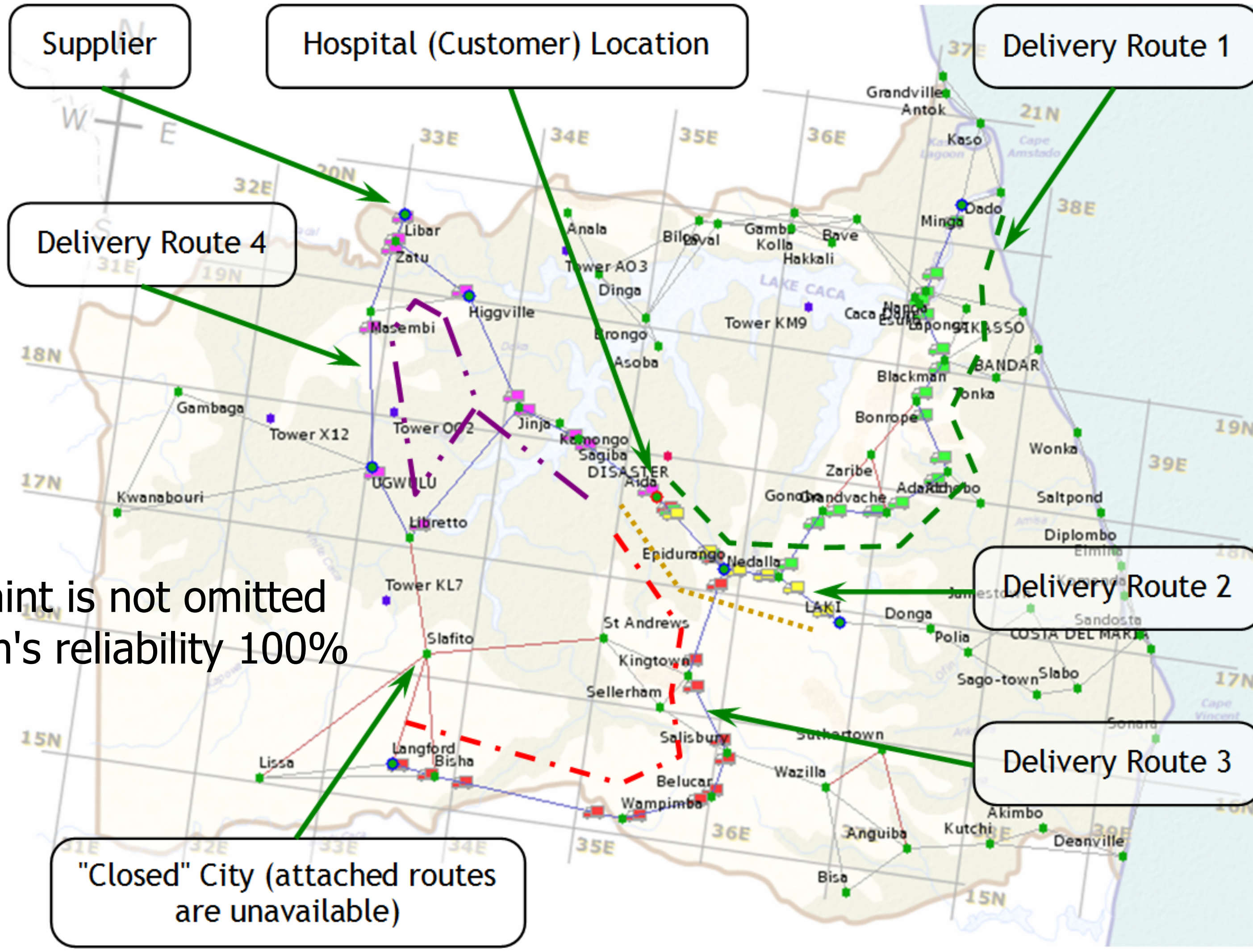
SPIIRAS



Constraint is omitted
Solution's reliability 64%

Case Study:
Example Result of User Request Processing

SPIIRAS



Constraint is not omitted
Solution's reliability 100%

Conclusions (1)

- Context-driven decision making is of on-the-fly agent-based intelligent service based on integration of ontology & context management and constraint satisfaction technologies .
- The context-driven knowledge integration approach for operational decision support is originally problem-independent and can be applied to different domains by creation of a new application ontology describing the new problems, and finding and attaching appropriate information & knowledge sources.
- Implementation of context-driven methodology can significantly facilitate flexibility and response speed of operational decision support systems for network-centric operations.
- Implementation of multi-agent technology together with semantic-driven interoperability create an opportunity for fast development of scalable DSSs.

Conclusions (2)

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- *Context-Driven Decision Making Approach* has direct relationships with following *Future Directions of ONR' Collaborative & Knowledge Management Program*:
  - Decision Making through Synthetic Experience,
  - Consultative Advisors,
  - Context-Sensitive Filters,
  - Reconfigurable Information Fusion Capability

Future Work: Motivation

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- Fast (time-critical) response for **megadisaster events** (massive hurricanes, earthquakes, nuclear attacks, etc.) requires emergency **preparedness** based on long-term **response scenarios** planning with realistic (or predictable) expectations concerning available (alternative) federal & local sources and estimation of access time to them.
- Major Megadisaster Response Management Issues:
  - scenario-based information fusion for operation preparing related to *typified situation;*
  - context-aware interoperability of operation participants based on *common knowledge & problem representation model;*
  - on-the-fly decision support assistance for officials based on *adaptive services*.

Future Work: Noncombatant Evacuation Operation

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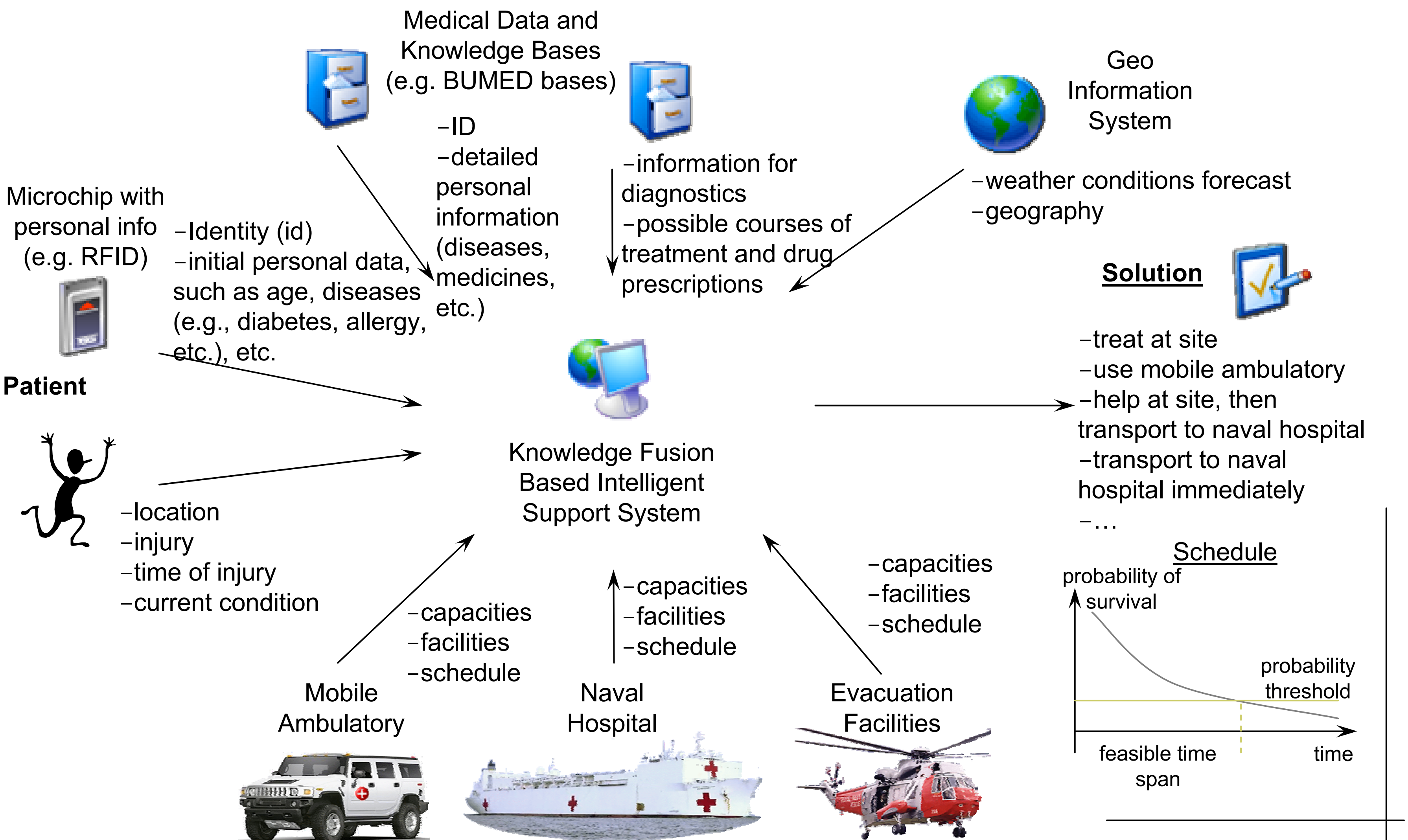
- **Purpose**
  - Producing efficient plans for treatment and evacuation of injured people based on information available in different sources
- **Information used**
  - Patient data: location, injury, time of injury, current condition, personal data (diseases, disease history, regular drug prescriptions, etc.)
  - Providers of evacuation facilities: the facilities
  - Weather conditions
  - etc.
- **Possible decisions**
  - treat the patient at site
  - send mobile ambulance to the site
  - send a helicopter to transport the patient to hospital
  - etc.

Future Work: Extended Information Environment



Future Work: Scenario

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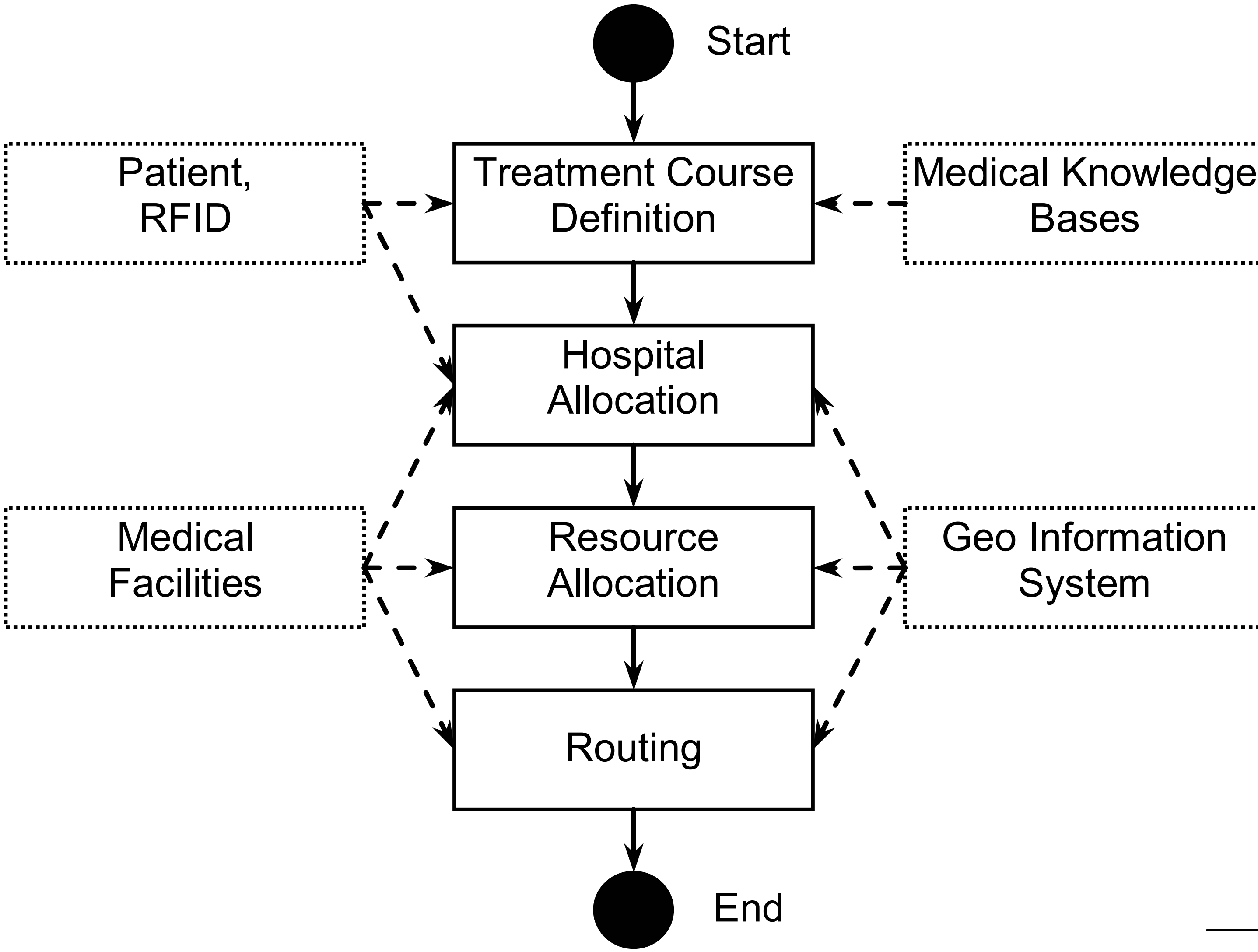

Future Work: Input of Preliminary Stage

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- Available scenarios and decision making methods / models / pattern / rules,
- Available information sources for decision makers,
- “National Context” descriptions - cultural specifics (behavior, values, etc) for different nationals, geographical regions, etc.
- Formats of external ontologies and information sources,
- Case study documentation

Thank you!

SPIIRAS

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